CHEMISTRY

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No Secrets

▶ DECLASSIFICATION of war secrets is the order of the day. From "Top Secret" to "Secret," from "Confidential" to "Restricted," the mumbo-jumbo of the medicine man gives way once more to the enlightened ways of science. War being a reversal of civilization, when it is in power the ways of the cave-man reappear. Individual bits of knowledge are hugged tight to the breast through general ignorance, fear and suspicion. When the hoards of the medicine men are shaken out the same jewels are likely to be found in each. Each wizard has been keeping the same secret.

From dark mysticism to shining clarity, sponsors of new products spread their announcements over the spectrum of credibility. "Our P.D.Q. No. 600, the better widget-filler"—better, obviously, than the same product under our competitor's label "X.Y.Z. No. 601." If one material has a silicon atom in a crucial spot where the other has a carbon atom, the user has a chance to take part in an enlightening experiment. If the user doesn't know what he is getting, who can blame him for preferring bear's grease?

The medicine man is arrogant, for he thinks his one little secret is the key to all knowledge. The scientist is humble, for he knows that the best our pooled resources can accomplish is nothing to brag of in the light of what needs to be done. The medicine man's secret dies with him. While he lives it cuts him off from the fellowship of those who are learning by experiment.

America's very strength as leader of the world in resources and scientific accomplishment may be a source of danger if we refuse to share our secrets with those who want to know.

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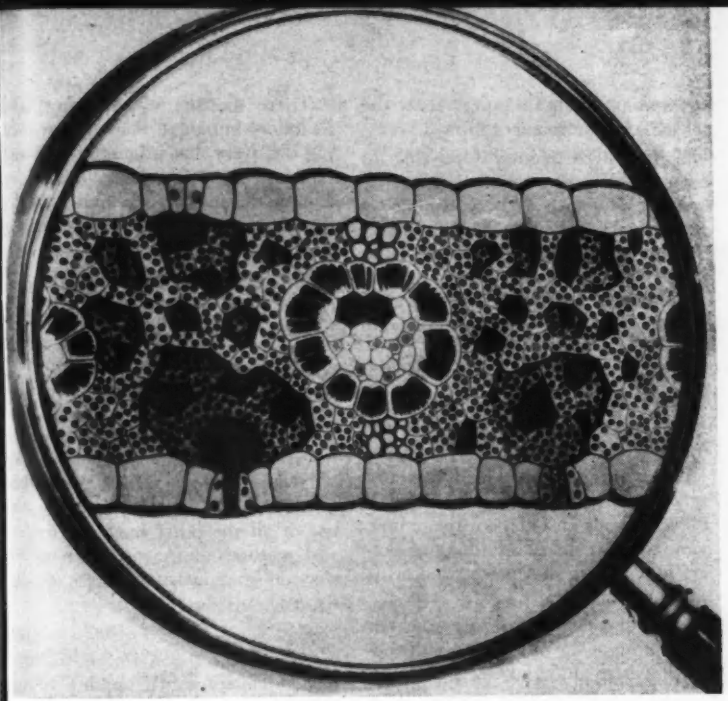

▸ SECRETS *hidden in the structure shown by this model of the cross-section of a green leaf must be learned before man can utilize the power of photosynthesis. Epidermal cell layers along the surfaces are seen to be pierced at intervals by stomata, flanked by guard cells. These open to admit oxygen and carbon dioxide as needed by the plant, and permit escape of water vapor and (in darkness) carbon dioxide.*

Next—Photosynthesis Secret?

by WATSON DAVIS

▸ THE RELEASE of atomic energy has stirred the imaginations and hopes of those who want cheaper and more plentiful power for more abundant living. For those confident that the world will handle satisfactorily the destructive possibilities of the atomic bomb, this may be the most important aspect of the fission of the atom and the practical realization of the conversion of mass into energy.

Atomic research and the manufacture of plutonium for the atomic bomb itself may give scientific research new tools that will bring results even more important from the

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standpoint of cheap power than the release of atomic energy.

If industrial plants were able to capture the sunshine with as great efficiency and with as little trouble as an ordinary green leaf, our civilization might be surfeited with available energy without having to use the energy locked up in the substance of the fundamental elements of our planet.

The secret of the green leaf, the mystery of photosynthesis, is a problem as intriguing as the release of energy from the atom.

It is a riddle upon which it would be well worth expending for research a few millions of dollars, if the atomic bomb was worth two billions of dollars for research and production, as it certainly was.

No full-scale determined research exploration of the photosynthesis problem has been undertaken. This is no criticism of the several research programs of modest size that have been attempted from time to time in this country and abroad before the era of war research. What we do know about this complex problem results from such independent inquiries into this phase and that of this most enticing research field.

Photosynthesis research is in much the state that nuclear research was some years ago. The equivalent of the fission of the uranium atom has not yet been discovered.

There are many promising leads to follow but there is as yet no exciting discovery that is detonating simultaneously in various places the equivalent of the nuclear research race that began just seven years ago, early in 1939.

This is all the more reason for extensive, well-supported and boldly-planned investigations.

The ability to "tag" carbon with radioactivity in the form of C_{14} a product of plutonium production places in scientific hands a powerful research tool. Other elements can be tagged in various ways and used as tracers. There will be need, too, for use of all the other new instruments and methods of science such as the electron microscope, ultramicroanalysis, etc.

The secret of the use of sunshine's energy by the green leaf is probably related closely to the nature of life itself, to the disastrously exuberant growth of cancer, and to the workings of the living cell. Science may start out to explore the starch and sugar factories in green, living things and along the way discover something much more important.

Suggestions of possibilities are contained in war and other recent researches. CHEMISTRY presents reports of some of these investigations in the hope that they may catalyse fruitful research.

Long-Lived Radioactive Carbon 14

➤ LONG-LIVED radioactive carbon, the production of which in relatively large quantity may well be one of the most valuable peacetime by-products of atomic bomb research, has been used for the first time in laboratory experiments, a group of University of California scientists have announced.

The experiments, which bring man a step closer to an understanding of photosynthesis and provide new techniques for a study of the basic life processes, were conducted with the only known supply of long-lived radioactive carbon produced before the war, a fraction of a gram prepared over an 18-month period by cyclotron bombardment.

Scarcity of the long-lived radio carbon has prevented its widespread use in nearly every scientific field. Use of the element as a "tracer" of living processes by means of the radioactivity is expected to yield a vast fund of knowledge of value in the advancement of medicine, agriculture and other sciences.

Carbon is the most common constituent of all living things, and its very omnipresence provides a yardstick of the potential value of radio carbon in bringing about further understanding of that element's functions.

With the development of the uranium pile technique, as described in the Smyth report, it may be possible to produce larger quantities of carbon 14 the longlived radioactive sister in the carbon family. The pile technique makes available a larger and steadier stream of neutrons, the particles used to produce carbon 14, than is furnished by the cyclotron.

The minute quantity of carbon 14 used in the Berkeley experiments was produced from 1,000 pounds of ammonium nitrate which were placed in tanks around the 60-inch cyclotron. Stray neutrons from the machine transformed some of the nitrogen atoms of the ammonium nitrate into carbon 14.

In the experiments just completed, the Berkeley scientists synthesized two simple organic compounds, acetic and butyric acid, by feeding heterotrophic bacteria radioactive carbon dioxide and ordinary sugar.

They succeeded in labeling all of the groups of atoms of the two compounds. Previously it had been possible to label one group of atoms in such organic compounds, using short-lived radioactive carbon, which is not suitable for many experimental purposes.

The research indicates that many organic compounds may be labeled in a variety of ways for tracer studies, and make possible the study of the building up and breaking down of food substances in human and other living systems. For example, it will be possible to study the conversion of sugars into fats in the animal body.

Transformation of carbon dioxide is ordinarily accomplished only by photosynthesis, in which green plants use water, chlorophyl and sunlight to produce all carbohydrates, proteins, fats and other plant products.

The ability to build up organic carbon molecules from carbon dioxide by biological means adds further knowledge on the still-mysterious photosynthetic process.

Several years ago a group of Berkeley scientists carried on experiments with carbon 11, another radioactive sister in the carbon family. However, carbon 11 has a half-life of only 21 minutes, giving researchers a maximum of four to five hours in which to experiment. Carbon 14 has a half-life of 25000 years, and is therefore suitable for long complicated chemical procedures.

The scientists who conducted the experiments are Dr. H. A. Barker, associate professor of soil microbiology; Dr. Martin D. Kamen, formerly of the Berkeley Radiation Laboratory and now at Washington University, St. Louis, Mo.; and Victoria Haas, graduate student.

Carbon 14 was discovered at the University of California in cyclotron bombardments by Dr. Kamen and Dr. Samuel Ruben, who died from an accident while conducting war research.

Quantity Production of Carbon 13

➤ FOR USE IN research on cancer, diabetes, arterial, heart and other diseases, carbon of atomic weight 13 will be produced in substantial quantities, the Sun Oil Company and the Houdry Process Corporation have announced.

This heavy carbon isotope has been used in biochemical research for the past two years and now two plants are to be constructed to produce it in larger quantity, increasing from 500 to 1000 times the world supplies of this chemical element.

Carbon 13 is concentrated by thermal diffusion, separating it from ordinary carbon 12. The new plants will bring the cost down to about $40 a gram, whereas the experiments were started with less than a half-gram which cost several thousand dollars to concentrate.

Carbon 13 serves as a tracer in chemical reactions in living and nonliving material since by its different weight it can be spotted and told from ordinary carbon.

The research was initiated by Dr. Aristid V. Grosse of the Houdry organization. The carbon 13 was produced under the supervision of Dr. E. A. Smith, director of Houdry research and development, while it has been distributed to biochemical research institutions by Dr. Stanley P. Reimann, director of Lankenau Hospital Research Institute of Philadelphia, who is secretary of the Isotope Research Committee.

Future to Harness Sunlight

➤ FUTURE generations may have to harness sunlight to obtain energy when other sources are exhausted, Dr. W. Albert Noyes, Jr., chairman of the University of Rochester chemistry department and president-elect of the American Chemical Society, told the ACS Virginia Section recently. Dr. Noyes said:

"In the distant future when supplies of coal and oil are gone and when all of the radioactive materials have been used up to give energy—or to destroy humanity—the earth will still be receiving energy from the sun. The effective use of that energy would of itself alone make the study of photochemistry worth while."

In many ways, Dr. Noyes pointed out, light is a good deal of a nuisance. "It fades the dyes in dresses, causes sunburn, ruins the rubber in tires and, generally speaking, causes all sorts of things to deteriorate.

"Photochemistry would be a pretty poor subject," Dr. Noyes said, "if all we had to do was to keep light from doing damage. In some respects light is known to be beneficial. It produces Vitamin D which pre-

vents rickets, it forms the basis for the photographic industry, and it is occasionally used in industry to bring about the synthesis of important industrial compounds."

Light is a form of energy, he noted, and when molecules absorb it they acquire large amounts of energy and behave "as if they had very high temperatures." Their behavior, however, may be controlled by regulating the color of light which is used and by choosing the kinds of molecules with which they are mixed, he said.

"Some molecules steal energy from others with great ease," Dr. Noyes declared. "Others are able to react with the molecules which have the energy. Certainly one of the most important processes in nature is photosynthesis, the growth of plants through the action of sunlight."

A study of how light affects chemical substances shows, according to Dr. Noyes, that a molecule which absorbs light must do one of four things with the energy which it has—it may lose the energy to other molecules, and heat them up; it may split into fragments; it may give its energy to other molecules and cause them to split into fragments, or it may give out light again or fluoresce.

"The big molecules found in nature sometimes fluoresce and sometimes split into fragments," he explained. "Those which fluoresce can sometimes store up energy for appreciable lengths of time. Indeed, the growth of plants would be impossible if this were not true.

"Those which split into fragments can undergo a very wide range of interesting reactions. The fragments can join up in new ways to form new molecules. Several examples of this type are known, but the difficulty in explaining these reactions often lies in their complexity and only in a few cases have sufficient accurate data been obtained to permit the chemist to state definitely what is going on.

"The easiest reactions to study are those which involve the very irritating gases, chlorine and bromine. Both these gases are colored, which means that they absorb ordinary visible light. A few commercially interesting compounds can be prepared photochemically with the use of chlorine. These reactions are, probably, better understood than most of the others."

Living Cells Under Electron Microscope

▶ SECRETS of the structure and functioning of the parts of the cells of which all living plants and animals are made may be revealed by use of the electron microscope, which shows details far finer than can be detected with the old-style light microscope.

Speaking at the 1941 symposium on the electron microscope, held by the American Physical Society, meeting with the Pacific Division of the American Association for the Advancement of Science, Dr. A. Marshak, of the University of California, told of some of the biological problems that the new instrument may solve.

"The cell, which is the structural unit of the higher organisms, is itself a highly organized body," he said. "At its surface is a membrane which determines which molecules and ions

of the surrounding medium will enter the cell body. It is known to be very selective in its permeability to simple ions. The biologist would like to know whether it has a reticulate or porous structure, whether it has a uniform thin lipoid surface or whether it is emulsoid. Different types of indirect evidence have suggested all of these possibilities. What is obviously needed is direct observation."

Other details, too, may be brought out, he said. One of these may tell more about the very important process by which plant cells, with the influence of sunlight, convert carbon dioxide and water into carbohydrates, which are foods for man and beast. Chlorophyll, the green coloring matter of plants, does not show this process, called photosynthesis, when in solution. It does so in the plant cells, where there are chlorophyll-containing bodies called plastids.

"A knowledge of the molecular structure and organization of the plastid may go far in helping us to determine what the photosynthetic unit really is and to understand the photosynthetic process itself," said Dr. Marshak.

Germ-Stopping Substances from Green Plants

➤ GERM-STOPPING substances with penicillin-like action formed by green plants apparently belong to the well-known group of organic compounds chemically classified as unsaturated fatty acids, Dr. H. A. Spoehr and his associates state in the 1945 Yearbook of the Carnegie Institution of Washington. Commonest use of fatty acids is in the making of soap.

Scientists in Dr. Spoehr's laboratory discovered, a year or so ago, that a one-celled green water plant known as Chlorella, secreted a germ-stopping substance, or antibiotic, into the water. They gave this substance the name of chlorellin. To get it in a more concentrated form in less time they tried grinding up dried masses of Chlorella and extracting them. What came out was a dark, oily material which had no particular germ-stopping power but which acquired it upon exposure to air and sunlight.

This oily stuff was identified as a fatty acid of the unsaturated series, that is, one capable of taking in still more oxygen. When more familiar unsaturated fatty acids such as lauric and linoleic were tried out they produced similar results: no action when freshly prepared, but germ-stopping effects after exposure to air and sunlight. Similarly, extracts made from leaves of a wide variety of green plants behaved like the chlorellin preparations.

On Back Cover

➤ ONE OF NATURE'S *millions of photosynthesis factories in operation. This decorative leaf pattern, showing rib and pore structure of a castor bean plant, photographed by Jon D. Dodds of Benton, Ky., was selected as the best plant life photograph in the Seventh International Salon of Nature Photography, conducted by the Buffalo, N. Y. Musem of Science in 1945.*

Chemistry Important In Biological Warfare Research

U. S. Ready For Germ Warfare

GERMS have been added to the atomic bomb, rockets and other new weapons that can be expected to be used in any future wars.

America's extensive preparations to combat and undertake biological warfare included researches undertaken by nearly 4,000 scientists, Army and Navy personnel, in four war laboratories in Maryland, Mississippi, Utah and Indiana.

Biological warfare was not used by the United States. While intelligence reports after the Japanese occupation showed that the Japanese army fostered offensive developments in this kind of warfare from 1936 into 1945, the report states there is no evidence that the enemy ever resorted to this means of warfare.

The biological warfare report, made to the Secretary of War by George W. Merck, special consultant for biological warfare, is notable in not mentioning any specific disease by name.

But it does define biological warfare as "the use of bacteria, fungi, viruses, rickettsiae and toxic agents from living organisms to produce death or disease in men, animals, or plants." These agents are distinguished from synthetic chemicals used as gases or poisons, or what is usually called chemical warfare. Biological warfare thus has a very wide scope.

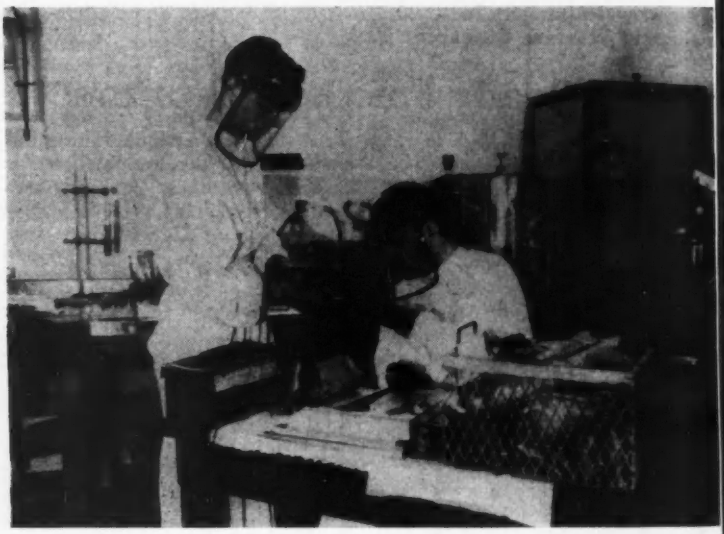
The report declares that biological warfare was used in World War I, and that "there is incontrovertible evidence that in 1915 German agents inoculated horses and cattle leaving the United States ports for shipment to the Allies with disease-producing bacteria."

U. S. Start in 1941

The possible use of biological warfare was brought to the attention of the War Department in the fall of 1941 and Secretary Stimson requested a National Academy of Sciences committee to survey the situation and future possibilities.

A supersecret committee called the War Research Service was organized in the summer of 1942 to take charge of biological warfare investigations. Working with the Army, Navy, U. S. Public Health Service, the National Academy of Sciences, the National Research Council, OSS, FBI and other agencies, this organization asked the Chemical Warfare Service of the Army to take over a large-scale development and research program in November, 1942. The first laboratories and pilot plants were begun in April, 1943, at Camp Detrick, Frederick, Md. Subsequently, field testing stations were established in Mississippi and Utah and large scale production was investigated at a plant in Indiana.

Only 60 cases of proven infection caused by accidental exposure to virulent biological warfare agents are reported during the researches and all recovered completely or are recovering. There were also 159 accidental exposures which received prompt treatment and did not develop infec-



—Official U. S. Navy Photograph

▶ RESEARCH WORKERS *in the Navy study of defense against biological warfare got much valuable information on control of communicable airborne disease, which will aid peacetime civilian populations.*

tion, except one case in which the exposure was not reported, the disease developed and the person recovered after treatment.

The biological warfare program was undertaken, the report states, "under the goad of necessity and aimed primarily toward securing for this nation and its troops in the field adequate protection against the possible use by our enemies of biological warfare agents. Adequate defenses were devised and the possibility of surprise from this quarter was forestalled."

Much information of great and lasting value for human welfare was obtained, the report claims. Unique facilities were established for research and experimentation on pathogenic agents on a scale never before possible.

Accomplishment of Program

Important accomplishments of the biological warfare program listed in the report are:

1. Development of methods and facilities for the mass production of micro-organisms and their products.

2. Development of methods for the rapid and accurate detection of minute quantities of disease-producing agents.

3. Significant contributions to knowledge of the control of airborne disease-producing agents.

4. Production and isolation, for the first time, of a crystalline bacterial toxin, which has opened the way for the preparation of a more highly purified immunizing toxoid.

5. Development and production of an effective toxoid in sufficient quantities to protect large scale operations should this be necessary.

6. Significant contributions to knowledge concerning the development of immunity in human beings and animals against certain infectious diseases.

7. Important advances in the treatment of certain infectious diseases of human beings and animals, and in the development of effective protective clothing and equipment.

8. Development of laboratory animal propagation and maintenance facilities to supply the tremendous number of approved strains of experimental animals required for investigations.

9. Applications of special photographic techniques to the study of airborne microorganisms and the safety of laboratory procedures.

10. Information on the effects of

▶ THE GUINEA PIG *in the experiment could be transferred in this holder from one apparatus to another, for observation under different conditions.*

—Official U. S. Navy Photograph

more than 1000 different chemical agents on living plants.

11. Studies of the production and control of certain diseases of plants.

Still more is to be learned about biological warfare, the report warns, and the research "must be continued on a sufficient scale to provide an adequate defense."

In organizing the world for peace, the report declares, "the potentialities of biological warfare cannot be safely ignored.

"Unlike the development of the atomic bomb and other secret weapons during the war," the report warns, "the development of agents for biological warfare is possible in many countries, large and small, without vast expenditures of money or the construction of huge production facilities. It is clear that the development of biological warfare could very well proceed in many countries, perhaps under the guise of legitimate medical or bacteriological research."

Pneumonic Plague?

Was pneumonic plague one of the diseases our military authorities expected the enemy to use against us along with V-bombs and other more conventional weapons of war?

The Navy's report of its share in our biological warfare research suggests that it was, although in this as well as in the War Department's report no specific germ weapons are mentioned by name.

Working behind a "blind" of much publicized studies on influenza, a Navy medical research team at the University of California developed a "Man from Mars" protective suit and other defenses against germ warfare.

To this team, Naval Medical Research Unit No. 1, headed by Capt. Albert Paul Krueger, was given the mission of investigating "the possible use by an enemy of a certain infectious disease."

The name of the disease is not stated but it is described as "centuries old and one of the greatest of killers." Elsewhere in the report are references to air-borne diseases.

Airborne diseases include such relatively harmless if unpleasant ailments as chickenpox and the common cold and such centuries old killers as smallpox, diphtheria, pneumonia, anthrax, and pneumonic plague. Against smallpox and diphtheria we have potent weapons of defense in vaccination, toxoid and antitoxin. Since the discovery of sulfanilamide, pneumonia has no longer rated as a great killer. That leaves anthrax, whose spores can be spread through the air, and pneumonic plague.

Pneumonic plague is caused by the same germs as bubonic plague. In the latter, the germs are spread by fleas from infected rats, ground squirrels and other rodents. The pneumonic form spreads directly from a plague patient whose breath carries germs from his infected lungs to the air.

Strengthening the idea that plague may have been the disease NAMRU No. 1 studied is the fact that its commanding officer is on military leave from his position as professor of bacteriology at the University of California at whose Hooper Foundation studies of plague have long been going on.

Germ Free Technique

Whether it was plague or some other disease, the Navy's research

—Official U. S. Navy Photograph

▸ Resembling *a "Man from Mars," this worker in NAMRU (Naval Medical Research Unit) ONE wears a rubberized protective suit in his investigation of infectious diseases.*

team escaped the killer it studied. No infections due to the organisms studied occurred among the investigators. Among the protective devices was an extensive modification of the apparatus devised for germ-free studies by Prof. J. A. Reyniers and associates at the University of Notre Dame. It consists essentially of a series of air-tight metal tanks fitted with sight and glove ports and built to contain all essential bacteriological equipment as well as experimental animals.

Before developing methods of defense against the disease, such as the Man from Mars suit for workers in prospective rescue or decontamination work, the Navy researchers investigated possible uses of the disease in offense. This involved development of new techniques for growing highly infective germs in great quantity and for ultimately dispersing them in mists.

Besides the rubberized protective suit with its own oxygen supply, the Navy researchers tested special antibacterial masks and vaccines, antibiotics (remedies of the penicillin class) and sulfa drugs. Summing up the 33 months of hard and dangerous work, the Navy reports that:

1. Considerable knowledge has been gained in mass defense against possible enemy employment of a certain disease, which is highly fatal.

2. Laboratory and field data have been gathered which demonstrate that a man-made epidemic as an instrument of war is a likely possibility.

3. A protective suit, with self-contained oxygen supply, has been devised for the use of workers in any prospective rescue or decontamination operation.

4. Conclusive information has been obtained which would be of great value not only for protection from bacterial attack but for control of communicable airborne diseases among a peacetime population.

Suspicion of DDT at First

▶ When the first shipment of DDT was received in this country, it was given a somewhat suspicious reception, for fear of possible Nazi scheming to let Americans poison themselves with the then strange chemical, Dr. Fred C. Bishopp, assistant chief of the Bureau of Entomology and Plant Quarantine, stated in an address before an audience of physicians.

Not that the shipment came from Germany; it was known to be authentically Swiss in origin. But it appeared to be a nerve poison, and it was thought that the German authorities might have given permission for the shipment to pass through territory which they controlled, in the hope that we might do ourselves some harm with it.

Subsequent tests demonstrated that in the forms in which it was prepared for insecticidal use, DDT is relatively harmless to human beings and other warm-blooded animals. In its first large-scale tests, in a louse-killing dust blown into the clothing of the inhabitants of North African and Italian cities, it stopped a menacing typhus fever epidemic; no subsequent harm to the people has been reported.

Chemical Warfare Research Brought Medical Benefits

BAL for As and Hg Poisoning

A SPECIAL ALCOHOL first developed by British scientists and made even more widely useful through research in this country, can now save patients poisoned by arsenic in the course of treatment for syphilis. Already 200 successful treatments have been reported.

There is hope that the same saving of lives may be accomplished in cases of mercury poisoning, such as occurs in use of bichloride of mercury in suicide attempts.

The alcohol that is more than an antidote for arsenic and probably mercury poisoning is 2, 3 dithiopropanol. A closely guarded secret during the war, this chemical has been known only as BAL (British anti-lewisite).

Its identity is now revealed by Prof. R. A. Peters of Oxford University, the biochemist whose 20 or more years of painstaking research between two wars resulted in its development.

BAL, the anti-arsenic chemical, was developed for use in local decontamination of the skin after lewisite poisoning. Lewisite, war gas developed by an American scientist, is an arsenic-containing chemical.

When the British shared the secret of BAL with American military and scientific authorities, scientists in the United States proceeded first to confirm the British findings and then to develop a practical ointment for use on the skin and in the eyes in case of lewisite poisoning. This was necessary because BAL itself is very unstable in water solution and some means of preserving its stability until it would be used was needed.

The very specific nature of the alcohol's action on arsenic in the skin suggested that it might be useful in cases in which arsenic had reached other tissues in the body, for example, in patients suffering toxic reactions from arsenicals used in treatment for syphilis.

American scientists next devised a method for using it in such cases. The method was to put up the alcohol in peanut oil and methylbenzoate. In this form it is stable and can be given by hypodermic injection.

Ampules of this form of BAL were distributed to all rapid treatment centers of the U. S. Public Health Service, where syphilis patients were getting large doses of arsenicals. From these centers records of more than 200 cases treated with BAL show that it is effective in counteracting arsenic poisoning. The failures are believed to be instances of too little or too late. The chemical was not given in large enough dosage or was given too late to help the patient.

BAL's action is more than that of an antidote. Antidotes merely take up whatever poison has not been absorbed by the tissues of the body before the antidote is given. BAL actually removes the poison from the tissues by forming a compound with the arsenic which the body can excrete.

Under the microscope scientists have seen germs "killed" by arsenic come back to life when BAL is put on them.

BAL itself has poisonous properties but these are not so great that it cannot be safely used if proper precautions regarding dosage are followed. It has been distributed to many doctors all over this country for scientific investigation. Manufacture for civilian distribution is planned but the chemical may not be available for several months.

Other Possible Cures

➤ OTHER PATIENTS whose eyesight is endangered by glaucoma, those afflicted with the muscle weakness disease called myasthenia gravis, and even sufferers from the mental illness, schizophrenia, may in future be restored to health as a result of other chemical warfare research.

These benefits from the search for new, more potent poison gases and for methods of combatting those that might be used against us are reported by Maj. Oscar Bodansky, M.C., of the medical division of the Chemical Warfare Service at Edgewood Arsenal, Md.

Myasthenia gravis and glaucoma patients may some day be grateful for the fact that British chemists, searching for new poison gases, investigated a chemical that might be popularly termed a nerve poison gas. One such selected for study caused excessive contraction of the pupil of the eye. It was hoped this chemical might be an effective weapon because it might make it impossible for a man to see well enough to shoot accurately.

As a chemical warfare agent it turned out to be a dud, but study of its action showed that it checked the activity of a body enzyme to an unprecedented degree. This enzyme is cholinesterase. Present treatment of both glaucoma and myasthenia gravis involves the use of prostigmine and physostigmine, substances which are believed to check cholinesterase activity.

The chemical warfare agent, not identified in Maj. Bodansky's report, checks this enzyme's activity for a much longer time, however, than prostigmine does. Studies are now under way to determine how effective it may be in treating glaucoma and myasthenia gravis and whether an even more effective chemical can be developed.

Successful search at Edgewood for a chemical to counteract the effects of hydrocyanic acid gas led to reinvestigation of the effects of cyanide on brain activity and the possibility of developing a successful chemical treatment of the mental disease, schizophrenia. Maj. Bodansky does not state in his report that such a treatment for schizophenia has been developed, but that a program for exploring the possibilities is now under way at one of the neuropsychiatric centers in this country.

The glimpses he gives of benefits to come from research at Edgewood and elsewhere on the medical aspects of chemical warfare show the importance of fundamental research. The work, he points out, "did not consist of haphazard, disconnected attempts" to find substances which might prove useful in treating gas casualties. It did consist of a systematic search for basic information.

Chem Quiz

What's the Dope?

▸ WEBSTER identifies dope with drugs, but also says something about some kinds of dope increasing efficiency. If you find your favorite stimulant here, you may comfort yourself with that. Anyway, see if you can identify the following formulas for chemicals with a definite effect on the human body. For instance, C_2H_5OH is ethyl alcohol. The rest are harder. Solutions of those you can't dope out are on page 50.

(1.) C_2H_5OH—its praises are widely sung, by some.
(2.) $C_{17}H_{19}NO_3 \cdot H_2O$—assuages pain.
(3.) $C_8H_{10}N_4O_2 \cdot H_2O$—is an eye-opener.
(4.) $C_{17}H_{21}NO_4$—benumbs the senses.
(5.) $C_2H_3O_2C_6H_9CO_2H$—is used for headaches.
(6.) $C_{17}H_{17}(C_2H_3O_2)_2NO_3$—is said to make one wild.
(7.) $C_{10}H_{15}NO$—is used for colds.
(8.) $C_9H_{13}NO_3$—we make this one ourselves.
(9.) $C_{10}H_{14}N_2$—is comforting to its users.
(10.) $C_9H_{13}N$—is a pep-er-up-er.
(11.) $CO(NHCO)_2C(C_2H_5)(C_6H_5)$—induces sleep.
(12.) $C_{18}H_{21}NO_3 \cdot H_2O$—helps the common cold.

Shark Repeller Saves Fishes

▸ THE SHARK-REPELLING chemical which was developed during the war to save the limbs and lives of "dunked" flyers and sailors promises to be a major money-saver to commercial fishermen. A test made at the suggestion of the U. S. Fish and Wildlife Service by the mackerel seiner Angie and Florence, operating out of Gloucester, Mass., showed that it was effective in keeping these toothy raiders away from a large net full of mackrel, saving both fish and net.

Shark attacks on heavy netfuls of fish have long been a major problem of commercial fishermen. The loss in fish is serious enough, but damage to the net may be even more so, for a good mackerel net costs several thousand dollars.

Results of the test were reported by Alfred Piscatello, crew member aboard the Angie and Florence. The vessel had circled a school of mackerel in its long net, when sharks were observed circling near. Two blocks of the shark-chaser were sunk to a depth of 20 or 30 feet in a weighted container, and towed around the net. Additional chemical was spread on the water close to the net. The sharks headed for the catch, but when they came to the black "slick" on the water formed by the chemical they hastily turned tail and swam away.

One shark was caught in the net. Ordinarily this would have resulted in serious damage, but this shark was very much subdued and was easily lifted out by hand.

Fire-Resistant Buildings From Waste Farm Materials

New Light-Weight Concrete

➤ LIGHT-WEIGHT concrete material suitable for building construction, that is fire resistant, insulates against heat and cold, is non-rotting and termite-proof, and cheap to make, has been subjected to laboratory tests during the past year at the University of Michigan and found particularly satisfactory for farm structures where the raw materials are easily obtained. It is made from ordinary portland cement, organic and inorganic fibers, and a small quantity of certain inexpensive chemicals.

The cement in the mixture is the binder; the fibers, obtained from farm wastes, contribute the lightness and bulk, and the insulation properties; the chemicals lessen the amount of cement required, prevent harmful shrinkage, and increase the strength. For fiber material, peanut hulls, cotton stalks, rice and wheat straw, cornstalks, flax shives and sawdust can be used. Among the best fibers are materials obtained from the northern jack pine, and winter-cut popple or aspen. Processing these woods is a simple grinding operation.

One of the disadvantages of this so-called insulative concrete is that the fibers require special preparation to remove harmful juices. The juices in ordinary farm wastes, such as straw and cornstalks, usually contain substances that are harmful to the set of the cement. It is not difficult to remove them, but the special treatment requires a certain amount of time.

Proper mixing is also important. Existing concrete mixers are made to mix heavy ingredients and are not entirely suitable for mixing this bulky light-weight material. They can be used, however, by using slightly more water than is ordinarily considered desirable in cement mixing to obtain the best results.

The insulative concretes vary in weight from one-third to one-half that of ordinary gravel concrete, depending upon the mix. Insulative concrete at half the weight of ordinary concrete is more crack-resistant, and at one-third the weight has ample strength for building construction. Two-inch boards of the new material showed, in the tests here, almost as great insulation value as two layers of celotex between facings of plywood and having a total thickness of slightly over two inches.

Slabs of insulative concrete will not support combustion, but will char when exposed to an intense heat such as a blowtorch flame. In use the new material will probably usually be cast into slabs and fastened over the building frame.

An economical way to feed fish is to feed with fertilizers the plants on which the fish live; plankton, the tiny organism sometimes called the staff of life for fish, grows rapidly after the addition of fertilizer to the water.

Atabrine Surpassed In War Syntheses

Better Anti-malarial Chemicals

THE WAR development of two new and powerful drugs against malaria was a triumph of American chemists.

Better than atabrine, much better than quinine is the synthetic chemical SN 7618 they created and sent to the Board for the Coordination of Malarial Studies for testing in April, 1944. This 7618th of the 14,000 substances tested for antimalarial activity turned out a winner.

As a suppressive, for holding the sickness of malaria at bay even though the parasites have invaded the body, SN 7618 needs to be taken only once a week, compared to the daily dose needed when atabrine is used for the same purpose. As a remedy, SN 7618 stops an attack of malaria in 24 hours, while atabrine takes four to six days to bring about recovery.

No yellowing of the skin goes with taking the white pills of SN 7618. It does not cause stomach and intestinal upsets. Its manufacturing cost is about the same as that of atabrine.

Chemically, this new antimalarial is a member of the 4-aminoquinoline series. German chemists at the I. G. Farbenindustrie plant at Elberfeld had previously, and unknown to American chemists, made 4-aminoquinolines as possible antimalarials and they even had made and patented SN 7618 itself, 7-chloro-4-(4-diethylamino-1-methylbutylamino) quinoline. But they discarded it as no good.

The triumph of American chemists consisted in recognizing its value and, even more, in developing a new method for synthesizing one of the intermediate chemicals needed to create SN 7618. Without this new method, SN 7618 could never have been made on a commercial scale, as it now can be.

Whether SN 7618 will ever be put on the market seems a little doubtful because other, even better antimalarial chemicals are in the works. One of these, an 8-aminoquinoline, shows promise of being a real cure for vivax malaria. Of three kinds of malaria, this one is most common in the United States and caused most trouble among our forces in the South Pacific.

Atabrine and SN 7618 cure falciparum malaria, a less common but more often fatal kind, actually removing the infection. They do not cure vivax malaria but merely stop each attack of chills and fever. The parasites are still in the body and can cause further attacks, or relapses.

Plasmochin, an 8-aminoquinoline developed in 1930, cures vivax malaria, but the dose for a cure is too close in size to the dose that causes poisoning symptoms. A safer chemical of this type, with a greater "spread" between curative and poisonous doses, has been developed and tested in patients. For 100 days the patients have gone without relapse of their malaria. If they do not have any relapses during the next 250 days, the scientists will feel sure this latest chemical is the long-sought cure for vivax malaria.

Many Substances Tested

Development of these two new anti-malarials was only a part of the work carried on in universities, government agencies and commercial firms by scientists whose efforts were coordinated by the Board for the Coordination of Malarial Studies.

Altogether, 14,000 substances were tested. These ranged from fertilizers, plasticizers, Nylon intermediates and rubber accelerators to Chinese herbs, mud from the River Nile, and eggshells suspended in choice whisky. Some, the Nylon intermediates, plasticizers and such, were picked from the shelves of organic chemical supply rooms. The odder items were sent by persons who had heard that eggshells in whisky, special muds, roots, herbs and so on, were good medicine for malaria.

The Board's scientists tested them all. It was easier, one member explained, to make the tests and send a scientific report than to write a letter explaining convincingly why the lower leaves of the cotton plant, for example, were not likely to prove a cure for malaria.

Chickens, canaries and ducks by the hundreds of thousands were used to screen the promising from the unpromising chemicals studied. Those which proved effective against the malaria parasites in these birds were then tested for possible poisoning action in mice and other animals, including thousands of monkeys obtained through the aid of the National Foundation for Infantile Paralysis.

When a chemical was found both effective and safe in these tests, it was tested in humans. For these last stages in the testing program, con scientious objectors and prisoners a federal and state penitentiaries volun teered.

Possibility of developing a vaccin agaist malaria was explored but ha not shown promise.

New knowledge of the malari parasites themselves and their bio chemical requirements has beer gained and has aided and probabl will further aid the search for chem ical cures and preventives of malaria

Intermediate Production

For a three-week period, chemist at the University of Illinois worke 24 hours a day, in three shifts, t speed production of a chemical need ed for making the antimalarial drug

The chemical is 4, 7-dichloroquino line. An original and simple metho of synthesizing it was worked out b two of the university's scientists, Prof Charles C. Price and Royston M. Rob erts, in August, 1944.

After Prof. Price and Dr. Roberts worked out the simple method of syn thesizing the intermediate chemical the 24-hour-a-day production schedul was followed until 20 pounds of thi chemical was made. This was enough for 30,000 doses of the final drug and enough for the clinical tests needed t determine its efficiency.

Working with Prof. Price on anti malarial chemicals were more than a score of chemists, including Prof. Reynold C. Fuson, Prof. Harold R. Snyder and Nelson J. Leonard. Prof. Carl S. Marvel of the university's chemistry department was a member of the Board for the Coordination of Malarial Studies set up by the National Research Council.

Vitamin A Synthesized; Next—Penicillin and Streptomycin

Closer to Chemical Production

➤ WAR RESEARCHES in biochemistry now made known show that one of the vitamins hitherto not made synthetically can now be made in the laboratory, and that important steps toward the synthesis of penicillin and streptomycin have been made.

Vitamin A Synthesized

➤ VITAMIN A, hitherto obtained from fish liver oils, has now been made synthetically, Prof. Nicholas A. Milas, of the Massachusetts Institute of Technology, has announced.

The synthesis was accomplished during the early part of the war but was kept a secret. War interference with the fishing industry caused a shortage of this vitamin, particularly important for growing children and necessary for eye health at all ages. To prevent wastage of the precious supply, the amount of the vitamin in multiple vitamin pills was restricted.

Now it appears that we were becoming independent of fish as a source of supply and need not worry over any future shortage of the natural vitamin.

Germany was also believed suffering from a shortage of this vitamin, in spite of the fact that she had access to some Norwegian fish liver oils. The acute shortage of vitamin A containing fats suffered by Germany and her allies during the first World War has been held responsible for the breakdown in morale that contributed to their defeat in 1918. These considerations led to keeping information about the synthesis of the vitamin secret for the duration.

Before the war, in 1937, one of Germany's leading organic chemists, Richard Kuhn, had announced a synthesis of vitamin A. Attempts by other scientists in Germany and other countries to synthesize the vitamin by his process, however, were entirely unsuccessful.

The M.I.T. workers investigated several processes before they succeeded in making the vitamin in the laboratory. The most successful process involves seven to eight chemical steps in which B-ionone, ethyl chloroacetate, acetylene, and derivatives of B-hydroxybutanone-2 are the principal raw materials used. Starting from B-ionone the vitamin A active product is produced in an overall yield of 10-15%.

The biological potency of the product is only one-tenth to one-thirtieth that of pure vitamin A crystals obtained from natural sources, but is 50 to 100 times greater than that of ordinary cod liver oil. The synthetic process has not yet been translated from the laboratory to commercial production.

Toward Penicillin Synthesis

➤ STEPS TOWARD synthesis of penicillin, anti-germ chemical which a humble green mold makes apparently with ease, have been announced by the Committee of Medical Research, Office of Scientific Research and Development, and by the British Medical Research Council in London.

Efforts of 38 different groups of scientists, 17 in Britain and 21 in the United States, have not yet succeeded in producing a synthetic penicillin, so far as the now published results show.

The several known antibiotics of the penicillin class all have the empirical formula $C_9H_{11}O_4SN_2.R$. The constitution of the R part of the compound is different in each of the penicillins. While the above formula tells the scientists which elements and how much of each are contained in penicillin, the way they are arranged in the penicillin molecule apparently has not yet been determined. This knowledge would be essential to synthetic production of the mold chemical in the laboratory. The two structural formulae to which workers in the field now are giving "the most active attention" contain respectively a beta-lactam structure and an azlactone grouping.

Since penicillin is now obtained on a commercially practical scale from the mold and since its chemical nature is so difficult to determine, it seems unlikely that synthetic penicillin will ever be produced outside of scientific laboratories. Efforts to synthesize it, however, will doubtless continue.

Streptomycin's Structure

➤ THE ACTUAL chemical structure of streptomycin, antibiotic that rivals penicillin as a remedy for infections, has been worked out almost completely by a group of scientists at the research laboratories of Merck and Company here. Details of part of the work were reported by Drs. Norman G. Brink, Frederick A. Kuehl, Jr., and Karl Folkers.

With this knowledge of the chemistry of streptomycin it may be possible to synthesize and manufacture the drug. In that case patients and their physicians would not be dependent as at present on the amounts of material that can be obtained by the tedious process of growing the soil organism, Streptomyces, and extracting the chemical from it.

Development and manufacture of a master chemical for germ-fighting that could replace streptomycin, penicillin and other antibiotics, or of a series of such chemicals, each designed for overcoming a particular group of disease germs, is another possible result of the discovery of how one such substance is put together chemically in nature. Hope for this is less solid than for the synthesis of streptomycin, difficult as that undoubtedly will be. The germ-stopping activity of antibiotics may depend on the entire chemical structure of the various substances, not on any part of it, and may be lost when the original structure is altered.

Streptomycin itself, the Merck researchers find, breaks up into two portions to which they give the "convenient trivial names" of streptidine and streptobiosamine. Together they are made up of 21 carbon atoms, 37 or 39 hydrogen atoms (the scientists are still uncertain of two hydrogen atoms), seven nitrogen atoms and 12 oxygen atoms. Streptomycin has the "general constitution of a hydroxylated base (streptidine) attached through a glycosidic linkage to a nitrogen-containing disaccharide-like molecule."

▶ A CAMOUFLAGED, *trailer-mounted, 1500-gallon-per-day compression distillation unit being operated by U. S. Marines on Saipan. Conditions under which compression distillation has successfully operated during the war were rugged.*

Fresh Water from Sea Was Heat-Saving War Achievement

Distillation Under Pressure

▶ MOST DISTILLATION is inherently wasteful of heat energy, for the liquid involved is usually boiled into a vapor and then condensed only to separate it from other materials. The liquid itself is at room temperature at both the beginning and the end of the operation, so that in principle almost all the heat consumed in distillation is recoverable. For many years engineers have been devising improved means for increasing this degree of heat recovery. Kleinschmidt compression distillation, the most recent step in this progress, follows a path different in principle from those previously explored, and was first used on a large scale during World War II, as a result of developments initiated in the laboratories of Arthur D. Little, Inc. The fuel consumption by this method is believed to be lower than by any other self-contained system of distillation.

In distilling sea water by the Kleinschmidt compression method, 175 or

more pounds of distilled water may be obtained for each pound of fuel consumed, a ratio three to four times greater than with efficient conventional systems using fuel to generate heat. This low fuel consumption proved of great value to the armed forces during the war; thousands of Kleinschmidt compression stills were manufactured under license by E. B. Badger & Sons Company and used by the services. In the Navy, use of these stills to make fresh water from sea water released space normally given to fresh water storage and, for many types of vessels, extended the cruising range to an extent that was strategically important. The Army and Marine Corps used Kleinschmidt stills in landing parties, particularly in desolate Pacific Islands. On Iwo Jima, for instance, the Marines continuously had fresh water from beachhead stills, although the Japs suffered desperately from its lack on this barren rock offering only a few useless hot sulfur springs. By the end of the war there was enough Kleinschmidt compression distillation equipment in service to produce pure distilled water for the daily needs of over a million men.

The principles of the Kleinschmidt compression distillation system were first publicly discussed recently before the American Society of Mechanical Engineers by Allen Latham, Jr., who headed wartime development of the method by Arthur D. Little, Inc. The development was initiated before the war by a group headed by Dr. (later Commodore) R. V. Kleinschmidt, who is now again associated with Arthur D. Little, Inc.

In distillation, heat is consumed principally in converting a liquid to a vapor; this heat is later released when the vapor condenses back to a liquid. In the Kleinschmidt compression system, the heat released is recovered by using it to boil the incoming liquid. Under normal circumstances this would be impossible, since the vapor condenses at the same temperature at which the liquid boils and heat would not flow between them. In the Kleinschmidt system, however, the vapor from the boiling liquid is compressed, which raises its temperature several degrees. The properties of steam and other vapors are such that when compressed they will condense back to a liquid at a higher temperature than normally. In distilling sea water, for instance, steam, at three pounds per square inch gage pressure, condenses to water at about 222° F., which allows enough temperature differential above the normal boiling point for the heat released by the condensing steam to flow to the raw water and boil it. In effect, the condensing vapor is used in place of externally supplied steam heat to boil the feed. No separate condenser or cooling water is needed.

Despite attempts to use the well-established principles involved in compression distillation, engineers did not consider it practical prior to the war; there were only a few specialized installations in Europe and none in the United States. Kleinschmidt compression distillation achieved widespread wartime use because early recognition of the value of the method led to inventions and a development program from which the present equipment emerged.

In conventional industrial distillation, the heat released by the condensing liquid is by no means thrown

away. In the multiple-effect evaporator the condensing vapor from the first still, or "effect," is used to boil liquid in a second "effect," where a vacuum is maintained to cause the liquid to boil at a subnormal temperature. There may be a third, and possibly a fourth, effect with increasing vacuums, but additional ones beyond four have been found mechanically impractical. The Kleinschmidt compression system offers in practice the equivalent of about 15 effects. In addition the compression still is much simpler.

The fuel economy of the Kleinschmidt distillation system is particularly valuable where waste steam is not available from other process operations. For instance, on diesel and gasoline propelled boats, such as fishing craft and small cargo vessels, the compression still, by replacing stored water, can release valuable space for cargo or fuel and increase cruising range substantially. In most distillation operations, the fact that the Kleinschmidt still does not use cooling water offers a definite saving, sometimes of critical importance. Compression distillation is, of course, applicable to liquids other than water, and in situations where the concentrated residue from distillation is desired rather than the distillate. For example, condensed milk or maple syrup may be concentrated from the parent liquids at favorably low temperatures by compression distillation. With the wartime needs now satisfied, Kleinschmidt distillation equipment will be available to industry.

Pvt. George Smith in Collier's Weekly.

"I told you to put them up! He loads it with acid from his chemistry set!"

Germany's Chemical Future

The closing session of the Chicago annual meeting of the American Institute of Chemical Engineers was addressed from Berlin by Dr. Albert Newman, on leave of absence as dean of engineering of the City College of New York, with OMGUS Industry Branch Economic Division in Germany. The views of this leading chemical engineer throw important light on the problems of occupying and making Germany safe for future peace. Dr. Newman's talk, here published through courtesy of the American Institute of Chemical Engineers, is followed by a number of summaries of reports of U. S. investigations of German war chemical activities.

Dr. Newman speaking:

➤ IT IS A GREAT privilege to be able to speak from Berlin to my professional group in the United States; the American Institute of Chemical Engineers assembled in Chicago.

In sending chemical engineers to Germany, our government has had several objectives.

First, there was the early mission of finding out what was new in Germany in processes and products. Findings could be useful in the prosecution of the Japanese war and to American industry.

Second came the problem of spotting and emasculating the installations designed solely for war needs.

Third was the problem of getting production started in plants capable of producing supplies for the occupying forces and the civilian population.

Fourth was the study of the level of chemical industry to be left in Germany under the Potsdam agreement.

Fifth was the achievement of this level of industry by reaching intelligent decisions as to which plants were to be declared surplus and therefore offered as reparations or destroyed.

Sixth was the setting up of controls to insure against the production of certain chemical products in excess of peacetime needs and possible export requirements. These controls would be implemented by a relatively small group of chemical industry intelgence men who would be on the alert to detect and report any indication of development of war potential.

It is obvious that the destruction of the purely war-potential-installations, and the starting of production in those whose products are urgently needed, are purely United States zone problems for the present, except for the constantly recurring necessity of arranging for raw materials and intermediates from other zones. It is not necessary to point out to chemical engineers the complexity of chemical industry, how one chemical plant depends upon other chemical plants for its materials. This complexity is not peculiar to Germany; we have the same thing in America. As soon as Germany can be treated as a single economic unit, as called for by the Potsdam agreement, some of these difficulties will disappear.

It is also obvious that the study of

the level of chemical industry to be left in Germany and decisions on reparations have to be made by quadripartite cooperation.

The Potsdam agreement set up time limits on quadripartite operations which force us to work on all phases at once.

It would seem logical to get the level of industry worked out and agreed upon before reparations were determined, but time pressure is so great on the reparations question that we must open some plants before a definite determination can be made about the need for these plants in the final economic balance to be established.

Again, we may find it necessary to give up plants which we know would have definite use in peacetime economy but which contain elements having excessive war potential, rather than expend the time necessary to make careful studies, followed by skillful chemical engineering surgery to eliminate the dangerous growths.

The destruction of single purpose war plants is well under way. Within recent weeks I have witnessed the blowing up of the great military explosives plants at Kaufbeuren and Ebenhausen in Bavaria. These were only the beginning of a large program of such demolitions outlined in Berlin and executed by engineer detachments under the orders of the Commanding Generals of the Third and Seventh armies, Generals Truscott and Keyes.

The problem of getting necessary production going in a nation as nearly in a state of industrial and economic collapse as Germany is now, can be seen to be a very difficult one. Foremost are the requirements of coal, coke, and electric energy. As an example I may state the case of synthetic nitrogen for use as fertilizer for 1946 crops. The Potsdam agreement makes it mandatory to maximize agricultural output. So, no matter what decisions may be made about synthetic nitrogen production in Germany when the final level is established, the chemical and agricultural people of four nations assembled here in Berlin have pointed out the urgeency of securing the highest possible nitrogen production in Germany before the spring planting takes place. The highest British, Russian, French, and American authorities have authorized that everything possible be done to get the nitrogen plants in their respective zones operating at their maximum capacities. Nevertheless, it has not been possible to deliver to these plants anything like their complete requirements of coal and coke. The United States Zone has only one nitrogen plant, a cyanamid plant in Bavaria, with electrical requirements normally furnished by water power. It is ironical that the rainfall in this part of Bavaria this year has been the smallest for 9 years, thus creating a shortage of waterpower to add to the other difficulties. This plant is limping along at only part capacity. Time does not permit me to outline the strenuous efforts which have been made to get this plant up to full capacity operation.

The shortages of coal and coke are better described as shortages of rail and water transportation. To anyone who has been in Germany it is not necessary to describe the wreckage of

bridges and tracks. The remarkable thing is that transportation authorities have been able to revive any railroad service whatever. Wonders have been accomplished. It also must be remembered that whatever railroad service there is must be used first to keep supplies moving to our armies of occupation. Only what is left can be used for essential German needs—industrial and otherwise.

Quadripartite estimates of nitrogen production, from now to the time of spring planting, based on the delivery of full requirements of coal, coke, and electrical energy, fall far short of the needs of nitrogen for 1946 German crops. Importing of 284 thousand metric tons of nitrogen between now and the spring planting are necessary if Germany is to have full crops for 1946.

The phosphate situation is equally shocking. Germany depended on basic slag, a by-product of steel manufacture, for two thirds of its agricultural needs for phosphate. Only about one third came directly from phosphate rock, none of which originates in Germany. Most of it came from the United States and North Africa. The steel industry is not in operation, and there are no imports of phosphate rock. German capacity for converting phosphate rock into fertilizer is less than one third of what is needed, and even these plants are idle. Imports of three hundred thousand metric tons of P_2O_5, (Editor's note: P_2O_5 is phosphorus pentoxide and is the chemist's manner of expressing phosphate content of fertilizers.) are urgently needed between now and spring planting to save the 1946 crops. What we are worried about is not so much the winter of 1945, but the winter of 1946, unless prompt action is taken to get the necessary imports moving.

One of the most acute immediate problems in Germany is that of finding raw materials for the manufacture of enough soap to provide a scanty ration for the population. During the war, Germany, instead of importing vegetable and animal fats for soap manufacture, depended largely upon synthetic fatty acids produced as by-product of synthetic motor fuel.

Representatives of the four nations are working strenuously on the future level of chemical industry. It is too early to give you any of the results. At this moment it is sufficient to state the fundamental American position on these negotiations. We are adhering closely to the provisions of the Potsdam agreement. We do not wish to see the clock turned back to the period of cave man existence in Europe. We realize that there can not be in existence at the same time, a Germany in a state of complete collapse and a prosperous France, Belgium, and Holland. There must be a level of living considerably above mere subsistence in all of Europe—otherwise the United States will be continually receiving appeals for aid. It must always be remembered that the prohibition of the manufacture in Germany of a product necessary to the peacetime economy of Germany, forces a corresponding import. For every such added import we must find an export to balance it.

We need and hope we have your support and backing in our extremely

difficult and trying task. We feel that we have a very great responsibility; what we do now in cooperation with our allies has a very direct influence on the future peace and prosperity of the world.

German Synthetic Fuel Manufacturing

▸ AMERICAN FUEL chemists, members of a government technical mission to Germany, uncovered German synthetic fuel manufacturing methods and brought back to this country information of value on how the Nazis kept fighting equipment in operation with little natural oil available. The methods are applicable in this country.

A preliminary report on the findings of the American chemists was given by Dr. W. C. Schroeder of the U. S. Bureau of Mines, before the meeting of the American Society of Mechanical Engineers. Full reports will be available later when other members of the mission have completed summaries of their findings. They will contain, Dr. Schroeder stated, "the best ideas generated through the years of research that the Germans spent on the synthetic oil industry."

The group of scientists went to Europe in March, 1945, about three months before V-E day, and remained to study synthetic oil plants in Germany as rapidly as they were seized by the Allies. Most of them had been knocked out by the Allied air forces but the debris was carefully studied. The examination was a tiring job of climbing over bricks, rubble, tanks and destroyed stairways. Additional information was obtained from scientists of France, Belgium and the Netherlands who were in a position to know something of the German methods.

Allied bombing raids put the Nazi fuel oil and petrol plants practically out of business, Dr. Schroeder explained, forcing others underground.

"Toward the end of the war, the demand for oil became so great that the Germans were frantic to increase production by any means," he said, "and 10 Meiler plants were ordered constructed. They were to be finished within a few weeks. The Allied advance was so rapid, however, that only four operated and these for less than a month. A fifth was ready but was never operated."

Some of the plants in Germany were of "tremendous size," and blending formulas, the amount of tetraethyl lead to be used in aviation gasoline or additives for lubricating oil were all specified in Berlin, he stated. In this way, "the make-up of the finished product was known only to a limited number high in the Nazi inner circle," he stressed.

"German synthetic production reached a peak of somewhat over 350,000 metric tons per month in 1944," Dr. Schroeder stated. "About the middle of that year, bombings became severe and production dropped rapidly. During bad weather, which forced reductions in bombing operations, production again picked up until the last month of 1944. Bombing again increased in intensity, and toward the end of the war synthetic production became practically insignificant."

Describing the gasification of the solid fuels manufactured by the Germans under their secret formulas, Dr. Schroeder said that "in general, both hydrogen gas for the production of synthetic ammonia and for the hydrogenation process, as well as mixtures of carbon monoxide and hydrogen for the manufacture of synthetic liquid fuels, waxes, and lubricating oils, were made by the standard water-gas process using coke as generator fuel, or by a combination of the latter process with the reforming of oven gas or straight hydrocarbon gas."

Germany, he found, has a limited supply of high-grade coking coal, but lacks a supply of the natural or hydrocarbon gas sufficient to meet their synthetic gas requirements. As a result, "earnest effort was made to utilize some of the non-coking coal for the production of synthetic gas" and considerable progress resulted.

"Two successful processes were developed for using the carbonized product which differ from those in common use in this country," he said. "They both use the char in a fine state of subdivision varying from one mm to ten mm in size, are continuous and have in common the use of mixed steam and oxygen—not air—as a gas-making fluid. The proportions of oxygen and steam in the mixture in each case were adjusted to maintain desired temperature conditions in the fuel bed.

"One of these processes was known as the Winkler process. The fuel under gasification in the Winkler generator was maintained in a fluidized condition, the particles being in ebullient motion, by virtue of the high rate of input of the oxygen-steam mixture. The resulting gas was a mixture of CO_2, CO and H_2. The proportion of these gases in the gas mixture was made variable within limitations by variation in the concentration of oxygen-steam mixture. The gas-making capacity of the Winkler generator was very high.

"The other process was the Lurgi-pressure-gas process, which gasifies the brown coal char under super-atmospheric pressure, with oxygen and steam proportioned to give the desired gas-making temperature, but in this case the fuel bed was stationary —not fluidized. The gas comprised CO, CO_2, H_2, and an appreciable amount of CH_4. The use of pressure, of course, favors the production of methane.

"Other processes were, or had been, under investigation, but apparently had not yet been carried to an entirely satisfactory state of commercial development."

German Hydrogen Peroxide Production

➤ WAR-ESSENTIAL hydrogen peroxide was made in Germany during the latter days of the European conflict through the use of easily oxidized organic materials, it is now revealed. Production by this new commercial method was still on a small scale at the end of hositilities but large-scale production appears to be feasible.

Conventional commercial methods of making hydrogen peroxide are electro-chemical reactions involving the oxidation of solutions of sulfuric acid or ammonium sulfate. It has been known for some time that reactions involving the oxidation of easily oxi-

dizable organic materials and the extraction of the resulting peroxide with water could be used; however, many factors limited the interest in these processes to laboratory investigation.

The methods discovered in Germany, in the Ludwigshaven plant of I. G. Farben Industries, were developed by two German chemists. The organic material was 2-ethylanthraquinone. The pilot plant in use had a capacity of over a ton of peroxide a day. Plans, however, had been drawn up for building a plant with a capacity 12 times as great, but construction had not been started when the war ended.

The process is covered by a German patent issued in 1941, of which copies are available here. The value of the discovery to America is that the feasibility of large-scale production of peroxide with relatively simple and inexpensive equipment by non-electrolytic methods has been proven.

Concentrated hydrogen peroxide has been called a new chemical tool which has many uses in industrial processes. The Germans used huge quantities in auxiliary devices for launching airplanes, V-bombs, naval torpedoes, jet-propelled planes and unmanned tanks. The production and use of this material was rated a top military secret by German authorities and elaborate precautions were taken to safeguard all information concerning them.

The information relative to this German method of making hydrogen peroxide was obtained during the postwar investigations of chemical production methods in Germany made by American scientists. The Ludwigshaven plant was visited and reported on by Ensign W. G. Gormley of the U. S. Navy. The report has been released by the Office of the Publication Board, U. S. Department of Commerce, and can be obtained by those interested.

Among other hydrogen peroxide plants visited and reported on is the giant peroxide factory at Bad Lauterberg, investigated by Lt. Col. Max Woldenberg of the Chemical Warfare Service. Construction of this plant was begun in 1939, two units were completed by the summer of 1941, two more in 1942, and a fifth in December 1944. Each of the five units had a capacity of 240 tons a month, 80% basis. The plant used the electrolytic method, starting with the electrolysis of ammonium bisulfate.

German Mercury Chlorine Cell

▸ A COMMISSION representing American domestic chlorine producers is visiting Europe to secure full technical information relative to the German mercury chlorine cell. Another group, in America, will determine the place and scope of tests for two types of the cell which will be brought to this country by the Army Chemical Warfare Service. Both committees are sponsored by this Army service.

The program to exploit the German mercury chlorine cell and make it available to American industry was launched by the Chemical Warfare Service in cooperation with the American chemical industry. This cell has been developed much further in Germany than in the United States, it is reported. It was given impetus by

war expansion of the German caustic and chlorine industry, abetted by the cheapness of mercury there due to relations with Spain, the mercury-producing country, during the war.

One advantage of the mercury cell is that it eliminates expensive evaporating equipment. A new vertical rotating type used by the Germans toward the end of the war requires much less floor space than conventional horizontal types.

A trend toward liquefaction of chlorine by means of higher compression, followed by water cooling without artificial refrigeration, was also noted in Germany by representatives of the Chemical Warfare Service in a survey of German chemical processes following VE-Day. A new type of rectifier, which was alleged to operate at high efficiency in the lower voltage range, was reported in at least two of the newer installations.

Improved methods of chlorine production will benefit the United States government, the chlorine industry and the American public. Large quantities of chlorine are now used in various industrial and other processes, particularly in bleaching and in water purification.

German Wool-Like Synthetics

➤ A SERIOUS wartime shortage of natural fibers in Germany, for clothing, canvas and rope, forced concentrated research, it is now revealed, directed toward the production of synthetic fibers with wool-like properties, and replacements for jute, sisal and hemp to make baling materials, rope and twine.

Germany obtained considerable wool from conquered countries, but the amount was insufficient for military uniforms. Its supply of cotton and rope-making fibers was very limited. Even before the war the plan of the Reich government was to make Germany independent, as far as possible, of the importation of raw materials for fibers, and also of natural fibers.

In the case of cotton, this was accomplished to a marked degree by the expansion of the rayon staple and tire yarn industries, but it was recognized that rayon staple fibers would not be entirely satisfactory for outside wearing apparel and for many technical and industrial uses.

German activities in the development of synthetic fibers has been studied on the ground since the close of the war by J. B. Quig of E. I. du Pont de Nemours and Company under a program of investigating German industrial and chemical methods sponsored by the United States government. His report has been released by the Office of the Publication Board, U. S. Department of Commerce.

The shortage of iron, steel and other metals, the report says, greatly stimulated the rapid development of hydrocarbon polymers and copolymers for the plastics industry. Some of these polymers were capable of being made into fibers and determined efforts were made to find polymeric fibers which would augment the natural fiber economy.

In the development of wool-like fibers, three lines of approach were followed. These were the modification,

physically or chemically, of viscose and acetate rayon fibers; the preparation of a synthetic protein fiber; and the application of water repellents to the fiber or fabric.

By the first line of approach, a crimped cellulose fiber of viscose, cuprammonium or acetate solutions was obtained that duplicates fairly successfully the superficial characteristics and processing characteristics of wool, but obtained only a limited success in imparting water repellency, permanence of crimp, and resiliency of handle.

Many other synthetic fibers are reviewed by the investigator. His conclusion, relative to the status of wholly synthetic fibers in Germany, however, is that progress in the United States compares favorably with it.

German Air Purification Devices

▶ AIR PURIFICATION devices developed in Germany for use in submarines, especially in the one- and two-man U-boats, appear to be well ahead of Western Allied developments, according to American official investigators who visited Germany under the sponsorship of the United States government.

Development work by the Draegerwerk, (Draeger factory) at Luebeck was investigated particularly, and especially work on air purification devices for underwater craft and for high-altitude demand regulators. An official report has been prepared, copies of which may be obtained from the Office of the Publication Board, U. S. Department of Commerce.

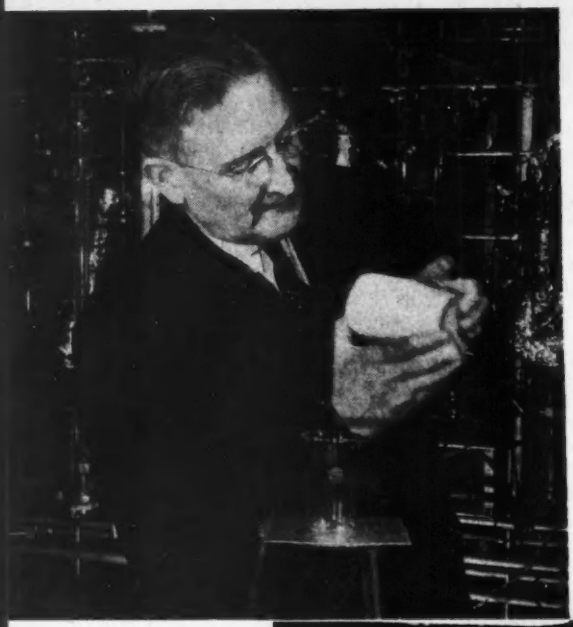
The Draegerwerk, well known for its production of precision instruments, was concerned with high-altitude oxygen breathing apparatus; submarine escape apparatus; diving apparatus; gas masks; oxygen cutting and welding apparatus; mine safety devices; swimming vests for pilots; rubber, surgical and technical goods, and other essential products.

Air purification devices for one- and two-man U-boats are important items. A less bulky system is required than ordinary equipment incorporating a fan and motor. This is particularly true in craft designed on the torpedo principle. The system developed at this plant was later used in German midget submarines.

Airtight Glass-to-Steel Fusing

▶ GLASS-TO-STEEL fusing, to make a permanent airtight seal for metal electron tubes, is now possible through a method developed here by engineers of the tube division of the Radio Corporation of America. It permits the use of a staple metal for the glass-to-metal seal in place of special alloys which are most costly and sometimes scarce.

The new method depends upon the control of processing so as to secure good "wetting" of the steel by the glass. Also it incorporates a mechanical design which provides compression strains at the glass-metal boundary, thus compensating for the difference in expansion of the two metals.



Thixotropic

➤ A SPECIAL *form of hydrated alumina forms with water a mixture whose curious properties are demonstrated by Dr. Francis C. Frary, Perkin Medalist, in these photographs, especially posed for CHEMISTRY.*

➤ WHEN SHAKEN *vigorously the thixotropic gel liquefies and pours like milk, for a brief period.*

Alumina Gel

➤ AFTER PART *of the alumina gel has been poured out it suddenly becomes solid, leaving, in some cases, an "icicle" hanging from the lip of the receptacle.*

➤ WHEN THE GEL *sets it is about as stiff as blanc mange, and the beaker may be inverted without loss of contents.*

➤ Dr. Francis C. Frary *(left), Director of Research of the Aluminum Company of America, who has just received the Perkin Medal for 1946, is admiring the mauve tie worn by Dr. Marston T. Bogert (right), Emeritus Professor of Chemistry of Columbia University. The linen tie was dyed with mauve, the first synthetic dye, discovered by Sir William H. Perkin, the first recipient of the Perkin Medal. Dr. Bogert has worn the mauve tie at every Perkin Medal Award dinner.*

Al_2O_3 Not Simple Stuff: Fluff, Blanc Mange, Corundum

Adventures with Alumina

by Dr. Francis C. Frary

The Perkin Medal for 1946, one of American chemistry's highest honors was awarded to Dr. Frary, director of research for the Aluminum Company of America, and this is the medalist's address delivered at the medal dinner in New York on January 11. Although his company is best known for its gigantic production of metallic aluminum, Dr. Frary devoted his address to his interesting studies of the oxide rather than the element itself.

When I started out in research many years ago I was an organic, not an inorganic, chemist. I was intrigued by the complexities of the compounds of carbon—untold thousands of them built up from simple fundamental types and related to one another through a vast network of reactions and properties. By comparison, inorganic chemistry sounded simple and tame: metals and non-metals, bases and acids, reacting with one another to form simple compounds which were strictly limited in number and related in simple fashion to each other. This apparent simplicity and lack of interesting possibilities in the field of general inorganic chemistry may account for its having been deserted by so many advanced academic workers for more enticing and apparently more remunerative fields. True, in recent years the physical chemists have developed many theories to unify and explain the vast accumulation of data in their branch of chemistry. My remarks tonight do not embrace that sort of complexity, but rather the factual complexity involved in what might be called the descriptive chemistry of some simple, common and useful inorganic compounds.

Since my own connection with research has been for many years largely administrative, that small part of the work of our Laboratories which I shall discuss tonight represents the work of various members of our staff, not my own work. In accepting this beautiful medal, I feel that I do it on behalf of my associates in Aluminum Research Laboratories and on the basis of their accomplishments. These, of course, cover a much wider field than the subject of my address, which is necessarily limited by your time and patience, but which deals with a material which is of vital importance in the aluminum industry. As an example, therefore, of what I might call complexity in simplicity, I would like to discuss briefly some of the work which our Laboratories have done with the very simple substance aluminum oxide and its simple derivatives.

Aluminum oxide and its hydrates present a variety of amazing contrasts. From the hardness of the sapphire to a softness similar to that of talc, from an apparent density of over two hundred pounds to one of about five

pounds per cubic foot, from high insolubility and inertness to ready solubility in acids or alkalies, and marked activity, the properties can be varied over wide limits. Some forms flow and filter like sand, others are viscous, thick, unfilterable or even thixotropic. Crystals may be of any size down to a fraction of a micron in diameter, with various allotropic forms, and there are also amorphous forms. Some varieties have a very high adsorptive power—others none at all. Some are catalytically active — others inactive. But they are all converted into alpha alumina (corundum) if heated hot enough and long enough.

The formula, properties, amphoteric character, etc. of aluminum oxide are, of course, well known. The ordinary form, corundum (designated as alpha alumina) and another variety called gamma alumina, have been frequently described in the literature. The oxide formed at lower temperatures, by the oxidation of the metal or the heating of the hydrate, is believed to be amorphous. As the temperature of heating the hydrate is gradually increased, X-ray spectra seem to indicate the development of a number of different phases, in addition to gamma alumina and the final end product (which begins to appear at temperatures above about 800°C), alpha alumina itself. Whether the differences of the spectra actually represent different phases or merely different crystal modifications or crystal sizes of the same phase, remains to be proved. The apparent simplicity of Al_2O_3 may be deceptive.

One of the most interesting properties of the varieties of Al_2O_3 formed by heating the hydroxide at about 400-500 degrees C. is their high adsorptive power for water vapor. Gases may be dried by them as completely as with phosphorus pentoxide, yet the adsorbed water may be easily driven off again at moderate temperatures and the adsorbent used repeatedly. This commercially valuable property is due to the extremely large surface area exposed by this porous material, and the affinity which this surface has for water. In our Laboratories, we have measured areas as high as 440 m^2 per gram for samples of these so-called "activated" aluminas. Practically every variation in any step in the process of manufacture of this material influences this area figure, so that the problem of producing a material with maximum adsorptive power combined with stability in use is a very complex one which must be solved by a large amount of ingenious experimental work.

The same type of alumina shows marked catalytic effects in the vapor phase treatment of gases at elevated temperature (cracking, hydrogenation, etc.) and these, of course, are enhanced or modified by the presence of impurities, either naturally present or purposely added. Extended heating naturally tends to recrystallize the Al_2O_3 into the stable alpha variety and shrink the structure so as to bring about a more or less gradual deterioration in surface area and catalytic properties. The influence of manufacturing and use factors, purity, etc. upon this deterioration rate is a fertile field for study and investigation.

One of the most important derivatives of aluminum oxide is the hydroxide, which may be thought of as

a compound of aluminum oxide and water. Actually, it is the ancestor of most commercial aluminum oxide, because the pure oxide is made by calcination of the hydroxide.

All chemists are familiar with the gelatinous, slimy, amorphous aluminum hydroxide precipitated from aqueous solutions of aluminum salts, but few realize the complexities of this system. Like most gels, this material contains large amounts of loosely bound water, over and above the actual water of crystallization. The analyst is accustomed to see a whole funnel full of the gel dry down to a few small, solid fragments. Actually, under the most favorable conditions, the maximum Al_2O_3 content obtainable in this gelatinous material seems to be about 10 per cent, and ordinarily it is less than this. When the gel is dried, X-ray patterns show that a crystalline hydrate has been produced, but slight differences in the conditions under which the gel was formed may entirely change the type of this hydrate. It may be either one of the two varieties of trihydrate (alpha or beta) or the alpha monohydrate, or a mixture of any of these; but never, so far as we know, the beta monohydrate. Why not? I wish I knew! Such simple facts as temperature and rate of precipitation of the gel are among the most important variables affecting the type of hydrate eventually obtained.

Speaking of gels, I would like to show you a sample of a thixotropic modification of hydrated alumina. If I shake the bottle vigorously, it becomes liquid and I can pour it into this glass. An instant's pause—it has now set to an inorganic "blanc mange," as you see. Another mystery of "simple" inorganic chemistry.

The crystalline hydrates differ among themselves not only in their X-ray spectra and crystal habits, but also in their chemical properties. The two trihydrates are quite readily soluble both in acid and alkali; the alpha monohydrate is relatively insoluble in acid, and requires higher caustic concentrations at much higher temperatures and more time to dissolve it, while the beta monohydrate (diaspore) is hardly attacked at all by caustic soda solution under the same conditions. The alpha trihydrate is the mineral gibbsite, which is the principal constituent of the bauxites found in North and South America; the beta trihydrate is unstable and not found in nature, while the alpha monohydrate is the principal constituent (boehmite) of the bauxites found in Europe.. Each of these hydrates behaves differently on calcination, the beta monohydrate (diaspore) going directly to a non-hygroscopic form of Al_2O_3 at a relatively low temperature, while the others at similar temperatures give amorphous or gamma alumina of varying degrees of hygroscopicity and reactivity. Presumably crystal lattice differences control this behavior, but what are they?

In general, the transformation of the gelatinous hydrates into the crystalline varieties on drying is irreversible, but the presence of a certain amount of chloride in the gel makes it readily susceptible to peptization in water, and this is the basis of some of the dried forms of "aluminum hydrate" used medicinally for the treat-

ment of stomach disorders. Recently we succeeded in producing a variety of dried reversible gel which does not contain chloride, and this has been found by Dr. Leroy U. Gardner* to be quite efficient in insolubilizing finely divided silica in the lungs of animals and preventing the development of silicosis, an effect not produced by any of the crystalline hydrates. Why should these two forms act as reversible instead of irreversible colloids?

The possibility of obtaining a relatively stable supersaturated solution of alumina in caustic soda, containing about twice the equilibrium concentration, and subsequently precipitating out the excess alumina as hydrate by seeding and gradual crystallization (extending over several days), is the basis of the Bayer process; but no one has yet found out why the decomposition of this supersaturated solution in the presence of a large amount of "seed" hydrate should be so gradual and relatively incomplete, in contrast with the usual behavior of supersaturated aqueous solutions. It would appear possible that there is an equilibrium between the sodium aluminate and some colloidal, highly hydrated form of the hydroxide, and that the delay in precipitation is in some way connected with the slowness of the removal of this highly hydrated material from the reaction by its transformation to the crystalline trihydrate.

After many years of work to increase the size of the precipitated hydrate particles, so as to reduce the dust losses in the aluminum plant, it became necessary to go to the other extreme and find the conditions under which particles half a micron or less in diameter could be regularly produced for use as a rubber filler.

The halides of aluminum are among its simplest compounds, generally resembling the well known chloride $AlCl_3$. This, in the anhydrous form, is very hygroscopic and extremely active catalytically, and in the hydrated form is very soluble. However, the fluoride differs sharply from the other halides in that the anhydrous crystalline material is substantially insoluble and its series of crystalline hydrates run the whole gamut of solubility. Why there should be two distinct hydrates having the approximate formula $Al_2F_6 \cdot 7H_2O$, one being practically insoluble and the other quite soluble, and a very soluble hydrate $Al_2F_6 \cdot 18H_2O$, is still a mystery.

Some years ago spectrographers began to report data which indicated the possible existence of aluminum halides where aluminum had a valence of 1, such as AlCl. Nothing was known of their chemical behavior until we discovered their peculiarity of apparently being capable of existing in the vapor phase at temperatures above about 800 degrees C. and decomposing spontaneously on condensation (at lower temperatures) into aluminum and the ordinary trivalent halide,* The monofluoride, for example, may be easily formed by heating a mixture of aluminum and AlF_3 in vacuo at temperatures above about 800°C, and condenses on the cooler parts of the equipment as a mixture of metallic aluminum and the

*Aluminum Therapy in Silicosis—J. Ind. Hyg., p. 211, Sept. 1944.

*U. S. Patent 2,194,705

ordinary anhydrous AlF_3. In our experience the oxide does not undergo similar changes, although a recent German patent claims to the contrary.

As far as I know, the sulfate and nitrate are more regular and normal in their behavior—perhaps because I know less about them. Both, however, form a series of soluble and insoluble basic salts, and the sulfate forms very insoluble double salts with soda and potash, which occur in nature as the mineral alunite.

Considering all of this factual complexity in one small corner of the inorganic field, I am led to wonder whether potential investigators have not been unduly dazzled by visions of the millions of possible compounds of carbon and the intricacies of physical chemical theory, overlooking the extremely interesting and practically important field of what might be called descriptive inorganic chemistry. If we look back to the great masters of the early days—Berzelius, Moissan, Wöhler, Perkin, Faraday and others—we find them to be masters of the facts of nature, absorbed in and fascinated by the intricacies of the behavior of the elements and their compounds. Much of the highly interesting and important factual basis of inorganic chemistry has now been relegated to the archives or to ponderous handbooks. Our crop of investigations of purely theoretical interest appears to have flourished at the expense of much needed work on the chemistry of the common and commercially important elements and compounds. It should be possible for some investigators to find as much of interest in the practical things of life as others do in some of the higher mathematical speculations which are so intriguing to the imagination. For the sake of the chemical industry which has to deal with the complexities of these so-called simple compounds, it is to be hoped that this field will not be indefinitely neglected.

We have been working on this problem of alumina for over twenty-five years, because cheap, pure alumina is a basic requirement of the industry, and are continually finding new things. Economies in manufacturing do not only depend on elaborate mechanical devices, automatic controls, etc., in spite of the advertisements of their manufacturers. Better knowledge of the details of the simple chemistry involved in a process is often the key to a reduction in cost or improvement in quality, and better analyses of a product may prevent a great waste of money and time on developments that cannot possibly succeed because of inherent defects in the product.

By a very careful study of the chemistry involved, the basis was laid for the commercial development of the Combination Process, which is the only improved alumina process developed during the war that has thus far proven to be commercially practicable. Low grade high-silica bauxite, when treated by the commercial Bayer process, produces a "red mud" byproduct containing 30-40 per cent of the alumina in the charge, and a corresponding amount of insolubilized soda. By a properly conducted calcination of this red mud with limestone and additional soda, 80 per cent of this alumina and 60-70 per cent of the soda can be rendered soluble. Upon leaching, under care-

fully controlled conditions, the sodium aluminate may be extracted and returned to the Bayer process, where it is recovered as standard grade alumina. Simple enough, but made practical only by years of intensive study of the chemistry of aluminates and silicates.

Other available raw materials for the extraction of alumina are tempting because of their greater abundance and wider distribution. From years of work on them we have come to the conclusion that the solution of the problem of economically utilizing them requires a more painstaking and complete investigation of the simple chemistry of alumina compounds, rather than some brilliant revolutionary theory or reaction. Complexity in simplicity still balks us—and beckons us on!

➤ THE PERKIN MEDAL *was founded in 1906 in commemoration of the 50th anniversary of the coal-tar color industry. The original medal was awarded to Sir William H. Perkin, who was the first to find out how to produce an artificial dye stuff. This dye, which is known as "Aniline Mauve," led to the foundation of the coal-tar color industry of today. The Perkin Medal Award is made annually to any chemist residing in the United States of America for distinguished services to the chemical industry. The medalist is chosen by a committee representing the Society of Chemical Industry,, the American Chemical Society, the American Institute of Chemical Engineers, The Electrochemical Society, and the Societe de Chimie Industrielle.*

Concentrate Alabama Iron Ores

➤ LOW-GRADE red iron ores of the Birmingham, Ala., district may produce marketable-grade concentrates with good recovery as the result of two promising methods developed at the U. S. Bureau of Mines laboratory, Tuscaloosa, in cooperation with the University of Alabama. It is an important discovery because the reserves of self-fluxing and high-lime ores of the area are being depleted by the war, and operators will ultimately face the necessity of treating lower-iron and higher-silica ores in their furnaces.

"Anionic flotation" is involved in the new methods, the conventional flotation methods having been found unsatisfactory. "Anionic flotation" is a process in which the undesirable impurities are floated, instead of the metal ores. Details of both methods may be obtained from the Washington office of the Bureau of Mines.

Dynamite Becomes Safer But Still More Powerful

Giant in Man's Service

by Dr. C. M. A. Stine
Vice-President Advisory on Research and Development, E. I. du Pont de Nemours & Co.

At a time when bullets, bombs, shells and torpedoes were taking up a large share of the day's news, the average citizen might be forgiven if he thought all the explosives in the world were going into munitions. Such, however, is far from the fact. Hundreds of thousands of pounds of explosives were being used every day in the routine job of keeping America growing and going.

Most important of these hard-working industrial explosives is dynamite. Its task, of course, was tremendously increased by the war, simply because war demanded in much greater amounts and for different purposes the raw materials used in peace-time —coal, iron and other metals, oil, cement, stone, potash. War also required more foundation space blasted from the rocky earth for factories and workers' homes. It required more and wider highways for the movement of men and supplies, and deeper channels in our rivers and harbors.

All these things dynamite accomplishes for us. These things and more. Dynamite drives the tunnels under our rivers and city streets and through our mountains. It bites out the gigantic chunks of earth and rock for our canals and railroad beds. It plows the ditches to drain our swamps and irrigate our farm lands. Much of modern civilization, in fact, whether in war or at peace, depends upon the efficient labors of this genii conjured up by scientific Aladdins.

The volume of dynamite put to work in the United States was about 425,000,000 pounds last year. Somewhere dynamite is being fired every hour of the day, in charges ranging from a few ounces, in the coal mines, to great 50,000-pound blasts such as those which hew valuable molybdenum out of a mountain at Climax, Colorado.

Metals were mined, rocks were quarried and tunnels and aqueducts were driven long before dynamite was invented and even before gunpowder was applied to engineering—an application said to have been started in 1613 in Germany. But the physical labor entailed in the pre-explosives era was tremendous and often of a type that only slaves could be forced to perform. One of the earliest improvements over the pick and wedge methods of mining was "fire-setting," in which the rock was heated up and then suddenly cooled with water so that it cracked to pieces. This technique was said to have been employed in ancient Egypt and Ethiopia and continued on up through the 16th Century. Burning fires deep down in mine drifts and shafts nearly suffocated the miners and the only means of ventilation were rather primitive. One was to wave large sheets of cloth either in the mine or over a shaft

opening, to agitate the air. The Roman historian, Livy, says Hannibal used "fire-setting" to clear part of his passage across the Alps. He cooled the hot rocks with vinegar, so the story goes.

Livy also records that it took 30,000 men, working eleven years, to hew out a three-mile aqueduct or emissarium through solid rock to connect Lake Celano with the River Garigliano, near Naples. Finished in 52 A.D. the tunnel was about 20 feet high and wide enough to accomodate two working cars. Figuring on the basis of a six-day week the tunnel was advanced at a rate of four feet per day, as contrasted to 50 feet a day in the case of some of our modern tunnels, which required considerably fewer men but which had the benefit of dynamite.

It has been calculated that in ditch-blasting a pound of dynamite will do in a few minutes as much work as a laborer would do in a whole day. And an actual test showed that in breaking up boulders on the farm dynamite is so cheap and quick that to meet its price (average, 20 cents a pound) in terms of hand labor a man would have to work for a cent and a quarter an hour.

This remarkable labor-saver celebrates its 80th anniversary this year. In 1866 Alfred Nobel, the famous Swedish scientist and later the founder of the Nobel Prizes, discovered that nitroglycerin, one of the touchiest of all high explosives, could be rendered relatively safe by absorbing it in kieselguhr, or diatomaceous earth, a material consisting of microscopic marine fossils and sometimes used for scouring powder. The nitroglycerin-kieselguhr mixture was packed in paper cartridges in the form of sticks that could readily be placed in bore holes. This was dynamite. Facilitating its use was the blasting cap of fulminate of mercury, which Nobel invented in 1867.

Dynamite has undergone many improvements since Nobel's day. Kieselguhr, itself an inert or non-explosive substance, has been replaced by so-called "active bases," made up of wood pulp, nitrate of soda, nitrate of ammonia, and occasionally other ingredients, which take part in the explosive action. This change has permitted great reduction of the quantity of nitroglycerin used. Today, when interruption of Philippine coconut oil imports has reduced the supply of glycerin, saving it is very important, and were it not for ammonium nitrate, produced synthetically in our own country, we would need 130 per cent more glycerin.

Dynamites have been made safe enough for use in the dusty and gaseous atmosphere of mines by addition of salts which keep the flame of explosion cool and brief and prevent it from igniting the dust or gas. Explosives of this extra safe type for mine use are called "permissibles." The old hazardous practice of thawing out dynamite in cold weather has been obviated by an antifreeze derived from ethylene glycol. This has reduced the freezing point of dynamite from 40 above zero to 40 below. Ethylene glycol itself is the material used in antifreeze compounds.

Improvements have been made, too, in the methods of using dynamite. The sticks are nearly always placed in bore-holes, and a modern drill

carriage can drill a dozen or more holes at one time, and at different angles. Such a carriage was used in laying the Pennsylvania Turnpike. A blasting cap is inserted into each hole with the dynamite and is wired to a blasting machine, a magneto which generates a current when the plunger is pushed down to spin the rotor. In the Pennsylvania Turnpike blasting several thousand holes were wired together and shot off at one time by one motor generator, an undertaking that required accurate computation of the voltages, amperages and resistances involved.

The demolishing ability of dynamite and blasting gelatin, another Nobel invention which incorporated guncotton with nitroglycerin, inspired several efforts in the 80's and 90's to use them as military explosives. Most famous of these ventures was the U. S. S. *Vesuvius,* nicknamed the "dynamite ship." Her huge guns, resembling long stovepipes, were made to fire by compressed air, since the shock of a propelling powder would have set off the blasting gelatin in the gun. The pneumatic equipment was so complicated that the guns had to be mounted rigidly and the whole ship aimed at the target. Each shell or torpedo was loaded with 500 pounds of blasting gelatin.

When the Spanish American war broke out the *Vesuvius* was assigned to bombard Morro Castle, at Havana, Cuba. But the shells only scarred up the castle lawn a bit. This enthusiastically heralded "secret weapon" was a fizzle. But dynamite and blasting gelatin, used as tools of industry, are far from a fizzle. They are among the most useful inventions of man.

Evergreen Plants on Planet Mars

▶ Adventurous travelers to Mars in the 21st century may welcome the sight of familiar evergreen plants which Prof. Gabriel A. Tikhoff of Tikhoff Observatory, Leningrad, believes exist on the planet.

In addition to the polar caps of ordinary ice and the moist green areas which flourish in early summer, there are other regions on the planet where plants grow that retain their color throughout the winter, Prof. Tikhoff stated.

Replying to opponents of the theory that plants live on Mars, Prof. Tikhoff said that conifers reflect the infrared rays of the sun less readily than deciduous trees, which lose their foliage every year. Since conifers are believed to protect themselves from winter's cold by this reduced reflection of infrared rays, which carry considerable heat energy, he stated, this feature would probably be even more strongly developed on Mars. This would account for the absence of great brilliance in infrare[1] photographs of the planet.

This winter Prof. Tikhoff plans to investigate further the plant life of Mars, he reported to the Soviet Scientists Anti-Fascist Committee. He will photograph the spectrum of various types of foliage from mountainous altitudes.

A carbon arc light of greater intrinsic brilliancy than that produced by the sun has been devised by man.

Chemical Advances Announced In U. S. Patent Grants

Patents Tell Chemical Progress

In the pages of the Patent Gazette and the complete copies of U. S. patents many of the latest developments in chemistry are most completely made known. This department that appears each month in CHEMISTRY *picks the highlights among the several thousand patents issued each month. Anyone may obtain a copy of a patent by ordering by number from the U. S. Patent Office, Washington, D. C., and remitting 10 cents in money order, cash or Patent Office coupon.*

"Antu," Rat-Killer

➤ "ANTU," A spectacularly successful rat-killing synthetic chemical, is now protected by newly issued U. S. patent 2,390,848. The discoverer, Dr. Curt P. Richter of the Johns Hopkins Hospital in Baltimore, has assigned rights to the government, through the Secretary of War.

The new rodenticide, which chemically is alpha naphthyl thio-urea (the initials spelling the convenience-name "Antu") is a kind of byproduct of research on rats' reactions to the intensely bitter taste of a related compound, phenyl thio-urea. Rats were reluctant to take this, but when they did it proved highly poisonous to them. So Dr. Richter sought a compound that would be just as poisonous but have no warning taste. Antu was the result.

Antu is almost completely insoluble in water, so is mixed with or dusted on baits in finely powdered form. An extremely fine powder of it will remain suspended in water for long periods, and may thus be taken by rats when they drink.

In experimental baitings in market and warehouse areas in Baltimore under the supervision of Dr. Richter, and in use elsewhere by the Army, rats have been killed by the thousands. Treated areas have remained rat-free for weeks and months afterwards. Antu has the additional advantage of being non-poisonous to animals other than rodents, unless taken in most improbably large doses.

DDT Patent Reissue

➤ IT IS NOT often that the U. S. Patent Office publishes a best seller, but they got out one recently—somewhat to their embarrassment when requests for copies continued to come in and they could not supply them immediately.

The unforeseen best seller was a reissue of the American patent on DDT —officially Reissue 22,700, to Dr. Paul Mueller, assignor to J. R. Geigy, A. G., Basel, Switzerland. Dr. Mueller is the young Swiss chemist who discovered the insecticidal value of DDT, and the Geigy firm is the original manufacturer. Reissue of the patent was necessary to correct some omissions in the first U. S. patent, No. 2,329,074, issued Sept. 7, 1943.

Following the usual custom, the Patent Office ordered 400 copies of the reissue—and had orders exhausting the supply before noon on the day

they were printed. A new printing has been ordered, and will be ready soon.

Blood Fractionation

➤ A NEWLY issued patent of unusual scientific interest is No. 2,390,074, taken out by Prof. Edwin J. Cohn, Harvard University biochemist. It covers the process he has developed for the separation of blood plasma into its constituent fractions: fibrinogen, globulin, albumin, etc, each of which was demonstrated by wartime medical experience to have its own special therapeutic value.

Separation of these compounds from the mixed solution that is plasma depends on extremely accurate adjustments of their respective acid-alkali balance, the electric charges carried by their molecules, the temperature, and finally the organic precipitating agents (alcohol, acetone, dioxane) used to bring them out of solution. Modifications of the process can be used in getting other proteins out of mixed solutions.

Rights in the patent are assigned to the Research Corporation of New York, a non-profit institution which devotes all proceeds from patents which it holds to the promotion of scientific research.

From H. E. to Varnish

➤ PENTAERYTHRITOL is one of the higher alcohols that made its debut before the general public as the basis of PETN (pentaerythritol tetranitrate), an explosive so violent that it has to be mixed with TNT to slow it down a bit. With its wartime job gone, "PE" has found another occupation: combined with fatty acids derived from linseed, tung or other drying oils it is claimed to make a superior material for use in varnish, enamel, linoleum, printer's ink and other products requiring quick drying and a smooth finish. If its molecule is first doubled up to form a polypentaerythritol the results are stated to be even better. On this new use of "PE," patent 2,390,202 has been awarded to Harry Burrell of Paramus, N. J., and Philip I. Bowman of Syracuse, N. Y., assignors to the Heyden Chemical Corporation of New York.

Phosphate Glass

➤ A NEW SOFT glass, in which a third or more of the mix consists of phosphorus pentoxide and the traditional sand (silicon dioxide) is omitted altogether, has been developed for use in cementing ordinary glass to metal, tile and other materials to which it has been difficult in the past to make it stick. The inventor of the phosphate glass, John E. Stanworth of Sheffield, England, has assigned rights in his American patent, No. 2,390,191, to the General Electric Company.

Dehydrating Method

➤ A RAPID dehydrating method for getting solids out of liquids is covered by patent 2,390,167, taken out by W. A. Patrick, Jr., and J. D. Elder, both of Baltimore. The liquid is flowed over a container filled with spheres to give a large evaporating surface. The vapor is drawn into a second container filled with silica gel, which becomes heated as it adsorbs the moisture. This heat is used to raise the temperature of a set of coils, where the partially evaporated solution is brought to complete dryness.

Lignin Converted

➤ WHAT TO DO with that chemical Cinderella of the pulp and paper industries, lignin, is the problem tackled

by a pair of German chemists, Karl Freudenberg and Willy Lautsch, of Heidelberg, who applied for a U. S. patent in prewar days. By hydrogenating the dissolved lignin under high pressure but at only moderate temperature, the lignin is converted into industrially valuable phenols and higher alcohols. The patent, No. 2,390,063, is vested in the Alien Property Custodian and is available for use by American manufacturers.

Glass Yarn

➤ EXTREMELY fine glass fibers are spun into yarn by a process on which Dr. J. F. Hyde, research chemist of the Corning Glass Works, has obtained patent 2,390,370. The fibers are bonded together and at the same time lubricated, through the incorporation into the yarn of one of the new organic silicon compounds known as organo-siloxanes.

Glass-Tempering

➤ AN IMPROVED method of tempering glass is the subject of two patents, Nos. 2,388,808 and 2,388,809. The first was taken out by Gerald White of Toledo, Ohio, and the second by Mr. White together with D. E. Grimes, also of Toledo. Glass is usually tempered by first heating it in a furnace, then blowing jets of air on its surface under pressure. In the first of the present two patents, the temperature and moisture content of the air thus used are closely controlled by passing the intaken air first through a dehumidifier, then through a heater, after which it is passed through the blower to the jets. The second patent covers an apparatus to support curved sheets of glass during the tempering process. The patents have been assigned to the Libby-Owens-Ford Glass Company.

Dries Frozen Foods

➤ SOMETHING new in food dehydration is embodied in the process on which Jay C. Hormel of Austin, Minn., received patent 2,388,917, which is assigned to the packing firm of Geo. A. Hormel and Company. The process is said to be particularly adapted to foods that are normally liquid or semi-liquid in character.

To start, the products are frozen, then cut into small chips or flakes. These are fed through a hopper into a slowly rotating screen drum within a vacuum chamber, in which they are subjected to the action of infra-red rays. Temperature is kept below the freezing point, so that the induced evaporation takes place from an ice surface—that is, it is sublimation rather than ordinary evaporation. This, the inventor states, avoids the off flavors that frequently result from evaporation at higher temperatures, even under vacuum.

Yeast Adhesive

➤ YEAST, cultivated on waste sulfite liquor from paper and wood-pulp mills, can be made into a high-grade adhesive by heating it to between 160 and 220 degrees Fahrenheit, states Eric W. Eweson of New York City, who has obtained patent 2,388,910 on his process. There is enough sugar in the waste liquor to feed the yeast, and lignin, usually also present, adds adhesive value. Another source of raw material for this process would be yeasts spoiled for other purposes through over-age or moldiness.

Soap Lubricant

➤ A MIXTURE of three kinds of soap which most people would never recog-

nize as soaps at all is the basis for patent 2,389,523, issued to Dr. Frank A. Leyda of Berkeley, Calif., assigned to the California Research Corporation. The ordinary sudsy soaps of bathroom and kitchen are compounds of either potassium or sodium with fatty acids, usually stearic or palmitic acids. When used with too-hard water, a flocculent precipitate, slippery but insoluble, sometimes comes out. This also is a soap—a calcium stearate.

To the housekeeper, such an insoluble soap is a plain nuisance, making troublesome rings in the bathtub or washbowl, but to the mechanical engineer metallic soaps of this kind are often very valuable greases. The grease on which Dr. Leyda has obtained his patent is a mixture: barium, calcium and magnesium compounded with stearic and palmitic acids.

Glass Metal Seal

➤ To OBTAIN better sealing contacts between glass and metals, particularly iron and steel, R. W. Goodwin of Cleveland Heights, Ohio, has developed a new glass formula, in which the oxides of lithium and aluminum, in relatively small quantities, are added to the old standard ingredients, predominantly silicon dioxide (sand) and the oxides of lead and potassium. The lithium gives a lower softening temperature, and the aluminum increases resistance to weathering and makes the glass easier to work. This glass is intended especially for use in such equipment as radio tubes and electric lamps; rights in the patent, No. 2,389,305, are assigned to the General Electric Company.

Rubber to Glass

➤ PATENT 2,389,641, issued to Donald V. Sarbach of Cuyahoga Falls, Ohio, and assigned to the B. F. Goodrich Company, represents the latest effort on the difficult problem of making rubber stick to metal and glass. Between the synthetic rubber coating and the metal or glass are not less than four layers of cement, the lower two of which contain finely divided metal or metallic oxide or carbonate particles.

Glass Fiber Insulation

➤ ALL-GLASS-FIBER insulation for electric wires is covered by patent 2,390,039, granted to Games Slayter and A. L. Simison of Newark, Ohio, assignors to the Owens-Corning Fiberglas Corporation. The matted or woven glass fibers are applied in various ways: as tapes, yarns, sleeving, etc.

Shark Repellent

➤ FORMIC ACID, the stuff that gives ants and related insects their characteristic, disagreeably sharp odor, is claimed by Alfred Dinsley of La Canada, Calif., to be an effective shark repellent. He states that when dissolved in sea water it gets into their gills and makes them depart immediately for less offensive areas. He proposes to incorporate formic acid in ground asbestos or other suitable carriers, to make repellent packets for the protection of aviators downed at sea. On this he has been granted patent 2,389,719.

Insect Repellent

➤ AN INSECT repellent, odorless, colorless, non-irritating to the skin, which will hold mosquitoes at bay for as much as six or eight hours, is based on compounds known as N-substituted butyl phthalimides. The inventor, S. I. Gertler of the U. S. De-

partment of Agriculture, has assigned rights in his patent, No. 2,389,427, royalty-free to the government.

Dextrose Sugar

➤ In a process for the production of dextrose sugar, undesirable colloids are removed from the solution immediately after the acid conversion of the starch by adding the extremely fine-grained clay known as bentonite. The acid is subsequently taken out by absorption in a synthetic resin. Rights in patent 2,389,119, issued on this process to Dr. S. M. Cantor of Riverside, Ill., have been assigned to the Corn Products Refining Company.

Synthetic Camphor

➤ A Swedish inventor, Fryderyk Schwartz of Stockholm, has taken out patent 2,389,389 on a process for the manufacture of synthetic camphor. Several formulae may be used, the raw materials being cymene and alcohol, with the addition of a mercury salt as catalyst.

Air Regeneration

➤ Regeneration of air fouled by breathing is the aim of a process on which patent 2,389,309 was granted to Nicolas Herzmark of Indianapolis. It is based on the absorption of carbon dioxide by compounds of barium, in particular the manganate, peroxide and ferrate of barium, to which sodium perborate is added, and the whole distributed through a mass of asbestos fiber.

Oil By Fire

➤ Heroic measures to get oil out of failing wells are contemplated in patent 2,390,770, granted to P. D. Barton of Phoenixville, Pa., and P. F. Dougherty of Chester, Pa., assignors to the Sun Oil Company. They propose to use underground fire, consuming part of the remaining oil to decrease the viscosity of the rest by heat and force it to the surface by pressure of the expanding gases. Air is pumped down into the oil sands and ignition is accomplished by means of a thermit bomb. Whatever combustible gases come up with the oil can either be sold or (preferably) pumped back down again to feed the fires. The fire is controlled partly through throttling the air supply, partly by pumping down water.

Swells When Hot

➤ An ingenious fireproof cabinet or filing case is the subject of patent 2,390,732, issued to J. H. Page of Muskegon, Mich., assigned to the Shaw-Walker Company. Instead of relying entirely on gypsum or other mineral that generates steam when heated, thereby often cracking the walls, the new system uses the mineral known as vermiculite, at least in part. This mineral has the peculiar property of greatly expanding when hot, so that it can be depended on to fill up the space made by the bulging of the cabinet walls.

Guayule Rubber

➤ Ira Williams of Borger, Texas, has undertaken to solve the problem presented by the rather high percentage of resins mixed with the high-grade rubber of the guayule plant. He uses a mixed solvent: alcohol or acetone mixed with a hydrocarbon like benzene or gasoline. This dissolves the resins and lets the rubber particles float free. Patent 2,390,860 has been granted on this method.

Stabilized Ergot

➤ Ergot, a drug used in obstetrical medicine, is prepared in a stabilized form according to the formula of Clair

S. Dyas of Pearl River, N. Y., who has assigned rights in his patent, No. 2,390,575, to the Lederle Laboratories, Inc. He adds thio-urea to a water solution of the ergot alkaloids, keeping the hydrogen ion concentration adjusted by means of an organic acid.

Magnesium Extraction

▶ DR. FRITZ J. HANSGIRG, notable Austrian metallurgist who escaped from Axis territory before the United States became involved in the war and has been working in this country since then, adds another to his string of patents on methods for extracting magnesium from its ores. This one involves the use of calcium carbide as the reducing agent. Rights in the patent, No. 2,390,531, are assigned to the Marine Magnesium Products Corporation of South San Francisco.

Dry Ink Pen

▶ ANOTHER foreign inventor whose work has attracted widespread attention recently is Laszlo Jozsef Biro of Buenos Aires, whose almost-everlasting fountain pen is already being widely sold. Now a U. S. patent, No. 2,390,636, has been issued on it. The pen writes by means of a freely rolling tiny ball point, supplied with an exceedingly thick, dense ink.

Outstanding Inventions of 1945

▶ THE FOLLOWING outstanding invention of 1945 have been picked from the thousands issued. Many of them relating closely to chemistry have been described in detail in the pages of CHEMISTRY:

A few of the outstanding inventions patented during 1945 are:

Anti-knock motor fuels, produced through the addition of compounds of heavy metals other than lead.

An activated clay filter that takes tetra ethyl lead out of gasoline and permits its use as a stove fuel or as a cleaning fluid.

An apparatus that super-powders coal to get maximum heating value from anthracites and other coals of high ash content.

An apparatus employing streams of electrons or gamma rays to search thick steel plates for hidden flaws.

A process that yields by the same operation magnesium, alloy steel and cement from silica-containing ores of magnesium.

A method for smelting magnesium directly from its silicate ores; a method for extracting magnesium from sea water, using the water-softener principle.

A low-pressure, low-temperature process for separating magnesium from its commoner ores.

Polymerized silicones used with additions of other chemical elements to make new resin-like substances.

A method of salvaging pure sulfur from hydrogen sulfide, through the use of sulfur dioxide under high pressure and temperature.

Electric wires insulated with a coating of sodium silicate that are flexible and not hygroscopic.

A plastic sheathing between copper wire and rubber insulations that protects the rubber from chemical damage by the copper.

An extremely hard tool steel containing carbides of tungsten or vanadium, made by a new sintering process.

A method for making wide strips of thin, flexible glass which can be used instead of mica for most purposes.

A sintering process that produces thin-walled articles by spreading the metal or carbide powder mixed with oil on the mold.

A system of microphotography on rectangular pieces of film suitable for filing in card indexes.

Chemical separation of actinomycin into two fractions, one of which is powerful in its action against certain microorganisms.

Simplification of the process for isolating gramicidin, germ-checking substance similar to penicillin, from bacterial cultures.

A high-wheeled locomotive with tubular boiler that permits a lower placement and better balance of weights.

A war-born high explosive called pentolite, consisting of PETN, mixed with TNT, insensitive to shock, but more violent than TNT.

A gas-mask filter medium made from highly adsorbent cellulose fibers.

Rubber separated out of macerated native goldenrod by adding an alkali salt to the flotation medium.

A method of freezing foods by constant agitation in a nearly saturated atmosphere, producing uncaked frozen products.

A method of preserving food by use of a highly volatile substance such as ethylene oxide or methyl bromide which does not injure the product.

Flexible plastic bags as containers for sterilized foods, instead of the conventional glass or metal.

A way of making for paint fillers silica grains as small as the smallest bacteria by pouring sodium silicate into methanol and bubbling carbon dioxide through the solution.

A new orange variety of high quality that ripens from five to eight weeks earlier than other Florida oranges.

A new type motion picture theater that has the screen on the ceiling and reclining couch seats.

A method for detecting small amounts of poison in the air by dissolving the gas molecules and then measuring the electrical conductivity of the solution.

A circuit of water channels that tests ship models as a wind tunnel does airplanes.

A flexible "iron lung" that encloses the torso only and enables the patient to change position and move more freely.

Synthetic chewing-gum bases consisting of fatty acids or hydrogenated resins.

Answers to Chem Quiz on Page 50

(1.) Ethyl alcohol
(2.) Morphine
(3.) Caffein
(4.) Cocaine
(5.) Aspirin
(6.) Heroin
(7.) Ephedrin
(8.) Adrenalin
(9.) Nicotine
(10.) Benzedrine
(11.) Phenobarbital
(12.) Codeine

Some Apparent Accident May Be the Key to Discovery

Repeat And Note The Glow

by Dr. W. R. Whitney

Dr. Whitney delivered this talk on the WGY Science Forum in Schenectady. He is honorary vice president and founder of General Electric's Research Laboratory

▶ Scientific research in countless fields is continually making changes for us. It seems possible that "We, the People" may continually improve by selective changes.

Modern alterations in our concepts of energy have been very significant. Not long ago we were sure of the conservation of matter and also of energy. But that was wrong; those laws had to be changed. The two things are interchangeable. We were right, however, in thinking that man ought to question everything, especially the obvious; and try everything, particularly the absurd. I want to review atomic energy in an odd way. Energy is ability to do work. Matter is the substance of everything. I need to know Einstein's equation, which shows how much of the one makes how much of the other, but I will omit it now.

I'm talking of changes (various kinds too) but nuclear energy changes are the latest. Folks have always asked: Are our continuing changes improvements? Do we need all these new ideas, thoughts, and gadgets? Wasn't the first monkey happy enough? Why should we continue to look up and climb up when we might so easily shut our eyes and slide down? But man learned that he does better by pursuing this upward way. No other animal can make that statement. When human beings finally discover ways to world peace, to creative happiness, to a common religion of human welfare, and are intelligent enough to continue appreciating the infinite creation, then our uphill trail will not have been too long. That's faith calling for works and I like it.

A dozen years ago a man could be arrested for carrying a bottle of beer, but not for carrying his gold coins. Now it is illegal to carry his gold, but he may carry the beer. Are such rapid changes good? I say yes; we are learning by experiment and are always trying to live and to be better.

When iron was discovered, some were sure it was bad because it made sharper knives than bronze did. But we found that it made stronger bridges. Moreover, we still are making newer steel tools, even rustless ones.

Was it wrong to learn that the flat earth was really round, and was not the center of the universe (as all but one thought) but went around the sun? Could we have remained ignorant of it forever? Somehow we naturally feel better for learning truth. Anything less than complete freedom to learn new truth would be terrible. Nowadays we begin to appreciate medical research, for example; our

wilder ancestors didn't care anything about it.

When Franklin and Faraday were curious about lightning and electricity, were they wrong? Electricity is part of a wonderful creation and who else but men could have possibly appreciated it?

Think of the discoveries of arithmetic from the time when fingers counted as high as we could go. Then came higher mathematics, including Einstein. Was that wrong? It is part of the uphill way to understanding and appreciating creation.

Before there were any chemists, alchemists tried to transmute metals and make gold. But real transmuting was first accomplished in 1919. Will that be bad for the race? I don't think so, but it will be tested in the future.

Fifty years ago at Boston Tech, I was helping boys do chemical experiments. We teachers had to see that they got something out of every exercise. One stunt was to make a hard-glass test-tube by using a gas-blast-lamp and nearly infusible glass. It was a trick to blow and anneal that tube so it would not crack when reheated. Then the student filled his tube with a weighed mixture of flowers of sulphur and iron powder. They were in the proportion of 32 and 56 (the respective atomic weights). One atom of each was to combine and make a molecule of iron sulphide. A little heat started a chain-reaction and a bright glow suddenly moved through the mixture. Then usually the tube cracked. The boy who had to write up each experiment and have it corrected would often overlook the crack and the glow. Thousands of times I wrote under that particular experiment, "Repeat and note the glow."

That forced some fine boy to make another hard-glass tube and do the sulphide experiment all over, merely to note a glow which he probably saw crack his tube the *first* time, darn it. To him that was just a regrettable accident. Hurrying because intrigued by the idea of next making that evil smelling sulphuretted hydrogen from his iron sulphide, he was impatient. Why had that teacher been so mean? The poor teacher had been forced to insist on complete and truthful experimental observations.

Now, after over half a century of experimenting, when I fail at something, I still often say to myself, "Repeat and note the glow."

Some apparent accident may be the very key I need and I may be grubbing dirt under foot when the morning sun is available. An accidental glow may bring out the golden color which I want.

Now we are beginning to learn a new science about nuclear power. This is enormously more exciting than atomic power (whose little heatglows cracked those tubes.) We used to insist on the equation Fe plus S equals FeS, and we taught that 56 plus 32 made 88 sulphide. A boy who imagined that that could be wrong to the *slightest* degree would be crazy; but it *was* wrong (to the *slightest* degree).

Today a glow means loss of weight. Matter loses mass when it radiates. But even in those early days chemists almost anticipated this, because in later thermo chemistry we wrote the equation 56 plus 32 equals 88 sulphide *plus* 220 calories of heat. We

could measure the glow but not weigh it.

The decay of atoms of Radium, an early nuclear process, gives too little glow to be visible to us; but it can be photographed. It's like x-rays. But we know that the lost mass which is half gone in 2500 years, is enough to continually heat an equal weight of water every hour from freezing to boiling point. So it's a considerable glow. Now consider the glow of the sun. The outside of the sun has a temperature of about 5000 C but its inner temperature reaches 20 million. We can't appreciate that much. Far below such temperatures things like our iron sulphide would be decomposed into atom parts. The high inner sun-temperature is believed to be due to reactions between nuclear parts, principally protons and neutrons as these combine. The simplest heat-source may be the process of making helium from hydrogen nuclei in the sun. Both these are known to be present there. The difference in mass before and after their combination is only a fraction of one per cent of the total mass, but as a glow it is enormous. That weight can account for the sun's radiation lasting billions of years. This gives an idea of the magnitude of nuclear reactions. These neutron-proton reactions can be looked at as cause and effect of the 20 million degrees temperature which still suits our ideas that heat is a form of motion.

So, whether we like it or not, the fields for research which are now opening up for us in the nucleus of atoms will enormously stimulate study of fundamentals—of things and of electricity—and will accelerate scientific progress to a new high. What ultimate results will be, no one can foretell, but I have full faith that it will be all for the pleasure and good of mankind.

Influencing Disease Resistance Through Diet

➤ RESISTANCE to virus diseases such as infantile paralysis can be influenced through diet but the exact method of doing it has not yet been worked out, Dr. C. A. Elvehjem of the University of Wisconsin told members of the American Chemical Society at Milwaukee.

Mice starved of vitamin B_1 are definitely more resistant to infantile paralysis virus than mice getting optimum or excessive amounts of the vitamin.

However, he pointed out, we cannot try to prevent infantile paralysis by producing universal beriberi, the disease which results from lack of vitamin B_1.

When all the facts are known, Dr. Elvehjem said, the effect of diet on disease resistance will undoubtedly not be related to the amount of a single vitamin or nutrition factor but more likely to the ratio of several different ones.

He warned against drastic changes in the diet until the effects on the total nutrition are known. Nutrition programs that are harmful instead of beneficial may result, he said, if "we use too extensively the fragmentary knowledge which is now available."

Boron and Aluminum

Classics of Science

The laboratory experiments which gave chemists their first glimpses of the pure elements.

Boron

ON THE DECOMPOSITION AND RECOMPOSITION OF BORIC ACID, *by MM. Gay-Lussac and Thenard. In Annales de Chimie, Paris, 30 Novembre 1808. Translated by Helen M. Davis.*

➤ WE ANNOUNCED in a note to the Institute the 21st of last June, and we published in the Bulletin of the Philomatic Society for the month of July, that in treating fluoric and boracic acids with the metal potassium there are obtained results which can be explained only by admitting that these acids are composed of a combustible body and oxygen. Nevertheless, since we had never recomposed it, we added that we have never claimed this composition as perfectly demonstrated. Since that time, we have continued and varied our researches; and we can state today that the composition of boracic acid is no longer problematical. In fact we decompose and we recompose this acid at will.

To decompose it, take equal parts of metal and of very pure and vitreous boracic acid in a copper tube to which a tube of bent glass is attached. Place the copper tube in a small furnace, with the end of the glass tube in a flask of mercury. When the apparatus is ready, heat the copper tube little by little until it becomes faintly red; hold it in this state for several minutes; then, the operation being ended, allow it to cool and take out the material. Here are the phenomena which are observed in this experiment.

When the temperature is about 150 degrees, all at once the mixture glows strongly, which appears in a striking manner if a glass tube is used. So much heat is produced that the glass tube cracks and sometimes breaks, and the air is almost always driven out of the vessel with force. From the beginning to the end of the experiment only atmospheric air is released with a few bubbles of hydrogen gas which do not amount to the 50th part of that given off when the metal combines with water. The metal is used up by decomposing part of the boracic acid; and these two substances are converted by their mutual reaction, into an olive gray material which is a mixture of potassium, potassium borate and the radicle of boracic acid. Extract this mixture in a tube by pouring water onto it and heating slowly, and separate the boracic radicle by washing with water cold or hot[1]; that which does not dissolve is the radicle itself, which shows the following properties.

This radicle is a greenish-brown, fixed and insoluble in water; it has no taste, it has no effect upon the color of either litmus or syrup of violets. Mixed with potassium chlorate or potassium nitrate and projected into a red-hot crucible, a vivid combustion results, of which boracic acid is one of

[1] Before washing, it is well to neutralize with muriatic acid the alkali which the solution contains; for it prevents the boracic acid being oxidized, and thus dissolved in the liquid to which it gives a very deep color.

the products. When it is treated with nitric acid a great effervescence results, even in the cold, and when the liquid is evaporated, much boracic acid is obtained. But of all the phenomena produced by the boracic radicle in its contact with other substances, the most curious and the most important are those which it presents with oxygen.

On projecting three decigrams of boracic radicle into a silver crucible at a faint red heat, and covering this crucible with a bell-jar of about a liter and a half capacity, full of oxygen and standing over mercury, it usually burns and the mercury rises so rapidly that it suddenly fills half the bell-jar. Nevertheless, in this experiment the combustion of the boracic acid

JOSEPH L. GAY-LUSSAC

BARON THENARD

radicle is far from complete. That which prevents it is that the radicle passes almost entirely into the state of a black oxide, which we believe we are the first to recognize, and, the outer parts of this oxide then passing into the state of boracic acid, this remains and so prevents the inner part from coming in contact with the oxygen. So, to burn it completely, it is necessary to wash it, and put it again in contact with oxygen gas, always at a cherry-red heat. But this time it burns with less force and absorbs less oxygen than the first time, because it is already oxidized; and the exterior part always passes into the state of boracic acid which remains, hindering the combustion of the interior: so to convert all to boracic acid, it is necessary to submit it to a great number of

successive ignitions and to as many washings.

In all these combustions, there is always fixation of oxygen without liberation of any gas; and all give acid as the product. Upon treating these products with boiling water there is obtained by suitable evaporation and cooling crystallized boracic acid, of which we have presented a sample to the Institute.

Finally, the boracic acid radicle behaves in air just as in oxygen, with the difference only that the combustion is less lively.

It follows then from all these experiments that boracic acid is actually composed of oxygen and a combustible body. We have proved conclusively that this body, which we now propose to call *bore*, is of a definite nature, which can be placed beside carbon, phosphorus, and sulphur; and we are led to think that to pass into the state of boracic acid it requires a great quantity of oxygen.

Aluminum

— On Aluminum, *by F. Wöhler. In Annalen der Physik und Chemie, Leipzig, 1827. Translated by Helen M. Davis.*

▶ To learn to know the physical and chemical properties of the elements which in the oxidized state make up the greater part of the surface of the earth, is from many points of view of greater interest than the study of many of the true metals; for upon our knowledge of these bodies depends in part our ability to imagine the formation of the earth's surface from the original material of volcanic eruptions and so forth.—Of all the radicles in the earth-substances in the most abundant kinds of soil, we have up to now learned to know only kieselearth, through Berzelius' experiments. H. Davy seems to have separated the radicle of clay, both by the agency of the electric battery upon a fused mixture of clay and potash, and by the action of potassium vapor upon clay at white heat. But in both cases it did not occur to him to separate the reduced metal from the remaining mass; so he could not have studied its properties.

Some years ago Oersted discovered an easy method of combining chlorine with the radicle of clay, by the application of a very ingenious method, which consists of allowing chlorine gas to stream over incandescent clay mixed with powdered charcoal. From this compound there is obtained then, by means of potassium-amalgam, an amalgam of aluminum, which oxidizes very quickly in air, and by distillation of the mercury the remaining aluminum can be recovered. Of the aluminum so obtained he says only that it was a lump of metal, of the color and luster of tin.

I have repeated this experiment of Oersted's, but got no positive result from it. By distillation of the potassium amalgam, after it was heated with the aluminum chloride, there remained at the end a gray molten mass of metal, which, however, evaporated when the heat was increased into a green vapor and distilled over as pure potassium. After this I looked around for another method, although I do not wish to say that it is not possible to reduce aluminum by this one.—Since Oersted noted at the end of his com-

munication that he could not look upon his researches on aluminum as complete, it might seem, although many years have passed since then, as though I have forced my way into a research successfully begun by another but uncompleted, because they promise new and perhaps more brilliant results. I must remark here that Herr Oersted himself encouraged me to pursue this research further.

Metallic Aluminum

The method for reducing and exhibiting this metal rests, it seems to me, on the decomposition of aluminum chloride by potassium and on the property of aluminum of not oxidizing in water. If a tiny piece of aluminum chloride be warmed in a glass tube with some potassium the violent reaction, accompanied by fire, shatters the tube. I then tried the reaction in a little platinum crucible, which succeeded very well. The reaction is always so violent that the cover must be fastened on with wire, so that it will not be thrown off, for the reaction, which gives off only a moderate amount of heat in the open, will suddenly of itself raise the crucible to red heat. Platinum will scarcely withstand it. On this account, to guard against possible contamination of the reduced aluminum with any platinum which may be lost, I always afterward made the reduction experiments in a little porcelain crucible, and went about it in the following way: Put into the bottom of the crucible a little piece of potassium free from carbonate, from which the kerosene clinging to it has been carefully removed. Cover this with a little piece of aluminum chloride of about the same volume. Then heat the crucible, covered with its lid, at first gently, until the combustion appears, which keeps going by itself, then strongly when this last is over. The largest piece of potassium with which I have attempted to work at one time up to now is ten balls the size of peas; in a Hessian crucible one could manage to operate with larger amounts. With these quantities the amounts of the reacting substances must be arranged so that either there is so much potassium that the reduced mass is alkaline, or so much excess aluminum chloride that it can be seen to evaporate at the moment of reduction.—The reduced mass is as a rule fully molten and blackish gray. The *fully* cooled crucible is dropped into a glass of water, in which the salt mass, under gentle heating, releases evil-smelling hydrogen gas and a gray powder separates, which on closer inspection especially in sunlight appears as composed of little scales of pure metal. After it has settled, pour the liquid off, put it on a filter, wash it with *cold* water and dry it. It is the metal aluminum.

Friedrich Wöhler

Electrolytic Process

UNITED STATES PATENT OFFICE

CHARLES M. HALL, OF OBERLIN, OHIO

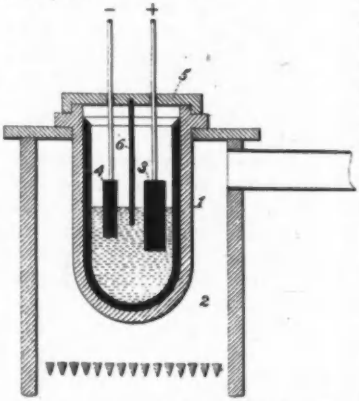
MANUFACTURE OF ALUMINIUM

SPECIFICATION forming part of Letters Patent No. 400,665, dated April 2, 1889

To all whom it may concern:

➤ BE IT KNOWN that I, CHARLES M. HALL, a citizen of the United States, residing at Oberlin, in the county of Lorain and State of Ohio, have invented or discovered certain new and useful Improvements in the Manufacture of Aluminium, of which improvements the following is a specification.

In applications filed by me July 9, 1886, and February 2, 1887, numbered 207,601 and 226,206, respectively, I have described and claimed certain processes for the reduction of aluminium, wherein I employ fluoride salts of aluminium or double fluorides of aluminium and electro-positive metals —as, for example, sodium or potassium—in a fused state to dissolve alumina, and the alumina is subjected to electrolysis when in a state of solution in the fused salts, thereby reducing aluminium at the negative electrode, the oxygen going to the positive electrode. The bath formed of the double fluoride of aluminium and an alkaline metal, as described in the above application, becomes less efficient after being subjected to electrolytic action for some time. This change does not result from any removal of aluminium fluoride or of fluorine from the bath, as no fluorine is separated; but a black or dark substance is formed in the bath, apparently from the alkaline constituent of the same, which interferes with a free electrolytic action and increases the electrical resistance; hence it has been found necessary when employing the salts named to change the bath after a continuous use of the same.



➤ DIAGRAM *of electrolytic apparatus in which Hall obtained metallic aluminum, from his 1889 patent.*

The object of the invention described herein is to provide a bath wherein the reduction of aluminium from its oxide may be carried on continuously without diminution and without increasing the electro-motive force of the current.

The accompanying drawing, forming a part of this specification, is in sectional elevation a form of apparatus applicable for carrying out my invention.

In carrying out my invention I prefer to employ a double fluoride of aluminium and calcium having a com-

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position represented by the formula $CaAl_2F_8$. This composition is formed by one hundred and sixty-nine parts of aluminium fluoride to seventy-eight parts of calcium fluoride or fluor-spar, the aluminium fluoride being artificially prepared by saturating hydrated alumina with hydrofluoric acid. The fluorides of calcium and aluminium unite in forming a double fluoride more fusible than the fluoride of calcium, and, as I believe, more fusible than either constituent alone.

While I prefer to use the double fluoride of calcium and aluminium represented by the formula $CaAl_2F_8$ in carrying out my process, there are a large number of similar double fluorides of the same metals which may be used and which closely resemble the one named, and answer almost, if not quite, as well as a bath for dissolving the alumina. Thus the double salt of the formula $Ca_3Al_2F_{12}$ has been successfully employed in the electrolytic reduction of aluminium. Whether the bath employed contains proportionately more or less aluminium fluoride within wide limits seems to make little difference.

In the practice of my invention the fluorides above mentioned are placed in the carbon-lined crucible or vessel 1, arranged in the furnace 2, and subjected to sufficient heat to fuse the material. Electrodes 3 and 4, formed of carbon when pure aluminium is desired, are connected to a suitable electric generator, as a dynamo-electric machine. If an alloy is desired, the negative electrode 4 is formed of the metal with which it is desired to alloy the aluminium. Alumina in the form of bauxite, anhydrous oxide of aluminium, or any other suitable form of alumina, preferably the pure anhydrous oxide Al_2O_3 artificially prepared, is then dissolved in the fused bath, and being subjected to the action of the electric current aluminium is reduced at the negative electrode 4, and, if said pole is formed of some heavy metal, forms an alloy with it, which drops off and sinks to the bottom of the bath. Oxygen goes to the positive electrode, and combining therewith when formed of carbon, forms carbonic acid gas or carbonic oxide, the carbon being gradually consumed. Alumina is added to the bath from time to time as the process is continued.

The solution of alumina in the fused bath of the double fluoride aluminium and calcium is apparently heavier than the metal aluminium, and hence this metal, if unalloyed, rises after being reduced and floats on the surface of the bath, where it is liable to loss by oxidation on contact with the air or with the positive electrode, where it is subjected to a strong oxidizing action; hence when reducing pure aluminium the crucible 1 is provided with a cover, 5, provided with openings for insertion of the electric conductors and the escape of gas from the crucible, and with a partition, 6, of carbon extending down into the bath and from side to side of the crucibles and separating the two electrodes. As the aluminium is reduced at the negative electrode alone, it will rise on the same side of the partition with said electrode, and hence will be protected by the cover and partition from any oxidizing influences, the carbonic gas and carbonic oxide being formed on the opposite side of the partition. As the operation continues, the cover is removed from time to time and the aluminium removed

The essential facts concerning
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from the surface of the bath.

When it is desired to form alloys of aluminium with iron, copper, or other heavy metal, the negative electrode is formed of iron, copper, or other metal with which the alloy is to be formed. The aluminium, as it is reduced at the negative electrode, takes up a portion thereof, and if the electrode is formed of heavy metal the alloy thus formed sinks to the bottom of the crucible. In forming alloys with heavy metals the cover and partition may be dispensed with, as the bath will protect the alloy from any oxidizing influences.

It may be stated that means may be used to lower the specific gravity of the bath by the addition to it of other salts lighter than the double fluoride of calcium and aluminium, so that the pure aluminium will sink in the combination and thus be protected from oxidation. Thus by the addition to the bath above described of about two-thirds its weight of the double fluoride potassium and aluminium, ($K_2Al_2F_8$,) which is comparatively a very light salt, is formed a composition lighter than aluminium, which will therefore sink when reduced and be thoroughly protected.

The double fluoride of aluminium and the alkaline-earth metals, calcium, strontium, and barium resemble each other very closely and may be employed interchangeably in this process—as, for example, the salts represented by the formulas $CaAl_2F_8$, $BaAl_2F_8$, and $SrAl_2F_8$, may be employed in the same way and the salts of strontium and barium, as well as other double fluorides of strontium and aluminium and barium and aluminium, may be used in the manner stated in regard to the double fluoride of calcium and aluminium. The salts of strontium and barium are heavier than the calcium salt, but more fusible, the salt of barium being the most fusible, and appear especially well adapted for the reduction of aluminium from alumina dissolved in them into its alloys with heavy metals, especially copper, the negative electrode in such case being formed of copper.

The double fluorides of aluminium and the alkaline-earth metals, barium, calcium and strontium resemble each other and differ from the double fluorides of aluminium and the alkaline metals, as potassium and sodium, in that they do not change in efficiency or action on being charged with alumina and subjected to electrolytic action for the reduction of aluminium, as is the case with the double fluorides of aluminium and the alkaline metals.

I claim herein as my invention—

1. As an improvement in the art of manufacturing aluminium, the herein-described method, which consists in fusing a combination of the fluoride of aluminium and the fluoride of an alkaline-earth metal, adding alumina to the bath so formed and passing a current of electricity through the fused mass, substantially as described.

2. As an improvement in the art of manufacturing aluminium, the herein-described method, which consists in fusing a combination of the fluoride of aluminium and the fluoride of calcium, adding alumina to the bath so formed, and then passing a current of electricity through the fused mass, substantially as set forth.

In testimony whereof I have hereunto set my hand. CHARLES M. HALL

Who's Who in This Month's Classic

JOSEPH LOUIS GAY-LUSSAC (1778-1850) was discoverer of the well-known law of expansion of heated gases. He began his scientific work with the famous French chemist Berthollet, and delighted his master by disagreeing with him. As professor at the École Polytechnique, at the Sorbonne and at the Jardin des Plantes, Gay-Lussac worked on a number of fundamental chemical problems, including, besides boron, the nature of chlorine and iodine and the compound radical cyanogen. In his later years he was drawn into industrial consultation and the political life of France.

LOUIS JACQUES THENARD (1777-1857) was a poor boy from the country who went to Paris to study pharmacy, fell in with the great chemists of his time, became a notable teacher, and ultimately was made a baron and a peer of France. He succeeded Vauquelin as professor at the Collège de France, and Fourcroy at the École Polytechnique and the Faculté des Sciences. He was a friend of Gay-Lussac throughout his professional life, and they carried out many researches together.

FRIEDRICH WÖHLER (1800-1882) was the chemist who broke the barrier between the organic and the inorganic worlds, and proved that mysterious life-forces are not necessary for the formation of the body chemicals. Pupil of Gmelin and of Berzelius, friend and contemporary of Liebig, his laboratory at the University of Göttingen was one of the centers of development of German chemistry. Much of his work was with metals, and aluminum was only one of several elements he isolated in metallic form.

CHARLES MARTIN HALL (1863-1914) invented the process for getting aluminum out of its ores in metallic form. Compounds of this metal are among the most abundant materials of the earth's crust, but it remained for this young American, only a few months out of college, to solve the particularly tricky problem of how to make use of some of them.

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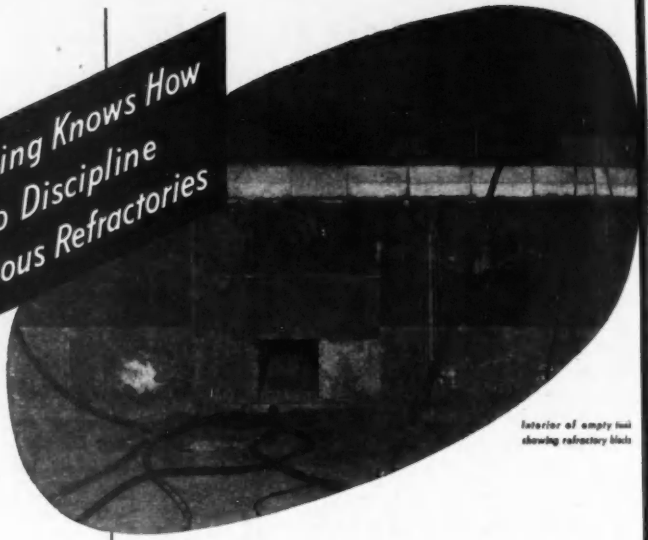

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